Excited $(\mathbf{70}, \mathbf{1}^-)$ baryon resonances in the relativistic quark model

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Abstract

The relativistic three-quark equations of the $(\mathbf{70}, \mathbf{1}^-)$ baryons are found in the framework of the dispersion relation technique. The approximate solutions of these equations using the method based on the extraction of leading singularities of the amplitude are obtained. The calculated mass values of the $(\mathbf{70}, \mathbf{1}^-)$ multiplet are in good agreement with the experimental ones.

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1. Introduction.

At low energies, typical for baryon spectroscopy, QCD does not admit a perturbative expansion in the strong coupling constant. In 1974 't Hooft [1] suggested a perturbative expansion of QCD in terms of the parameter $1/N_c$ where N_c is the number of colors. This suggestion together with the power counting rules of Witten [2] has lead to the $1/N_c$ expansion method which allows to systematically analyse baryon properties. The success of the method stems from the discovery that the ground state baryons have an exact contracted $SU(2N_f)$ symmetry when $N_c \to \infty$ [3, 4], N_f being the number of flavors. For $N_c \to \infty$ the baryon masses are degenerated. For large N_c the mass splitting starts at order $1/N_c$. Operator reduction rules simplify the $1/N_c$ expansion [5, 6].

A considerable amount of work has been devoted to the ground state baryons, described by the $\mathbf{56}$ representation of $SU(6)$ [7-11].

The excited states belonging to $(\mathbf{56}, \mathbf{L})$ multiplets are rather simple and can be studied by analogy with the ground state. In this case both the orbital and the spin-flavor parts of the wave functions are symmetric. Explicit forms for such wave functions were given in Ref [12] for the $(\mathbf{56}, \mathbf{4}^+)$ multiplet.

Together with color part, they generate antisymmetric wave functions. Naturally, it turned out that the splitting starts at order $1/N_c$ as for the ground state.

The states belonging to $(\mathbf{70}, \mathbf{L})$ multiplets are apparently more difficult. In this case the general practice was to split the baryon into excited quark and a symmetric core, the latter being either in the ground state for the $N = 1$ band or in an excited state for the $N \geq 2$ bands. Recently Matagne and Stancu have suggested the new approach [13] for the excited $(\mathbf{70}, \mathbf{1}^-)$ multiplet. They solved the problem by removing the splitting of generators and using orbital-spin-flavor wave functions.

The excited baryons are considered as bound states. The basic conclusion is that the first order correction to the baryon masses is order $1/N_c$ instead of order N_c^0, as previously found. The conceptual difference between the ground state and the excited states is therefore removed.

In the series of papers [14-18] a practical treatment of relativistic three-hadron systems have been developed. The physics of three-hadron system is usefully described in term of the pairwise interactions among the three particles. The theory is based on the two principles of unitarity and analyticity, as applied to the two-body subenergy channels. The linear integral equations in a single variable are obtained for the isobar amplitudes. Instead of the quadrature methods of obtaining solution the set of suitable functions is identified and used as basis set for the expansion of the desired solutions. By this means the couple integral equation are solved in terms of simple algebra.

In our papers [19, 20] relativistic generalization of the three-body Faddeev equations was obtained in the form of dispersion relations in the pair energy of two interacting particles. The mass spectrum of S-wave baryons including u, d, s-quarks was calculated by a method based on isolating the leading singularities in the amplitude. We searched for the approximate solution of integral three-quark equations by taking into account two-particle and triangle singularities, all the weaker ones being neglected. If we considered such an approximation, which corresponds to taking into account two-body and triangle singularities, and defined all the smooth functions of the subenergy variables (as compared with the singular part of the amplitude) in the middle point of the physical region of Dalitz-plot, then the problem was reduced to the one of solving a system of simple algebraic equations.

Section 2 is devoted to the construction of the orbital-spin-flavor wave functions for the $(\mathbf{70}, \mathbf{1}^-)$ multiplet.

In Section 3 the relativistic three-quark equations are constructed in the form of the dispersion relation over the two-body subenergy.

In Section 4 the systems of equations for the reduced amplitudes are derived.

Section 5 is devoted to the calculation results for the P-wave baryons mass spectrum (Tables I-VI).

In Conclusion, the status of the considered model is discussed.

In Appendix A the wave functions of P-wave baryons are given.

In Appendix B the relativistic three-particle integral equations for the $(\mathbf{70}, \mathbf{1}^-)$ multiplet are constructed.

In Appendix C the reduced equations for the $(\mathbf{70}, \mathbf{1}^-)$ multiplet are obtained.

2. The wave function of $(\mathbf{70}, \mathbf{1}^-)$ excited states.

Here we deal with a three-quark system having one unit of orbital excitation. Then the orbital part of wave function must have a mixed symmetry. The spin-flavor part of wave function must have the same symmetry in order to obtain a totally symmetric state in the orbital-spin-flavor space.

For the sake of simplicity we derived the wave functions for the $(10, 2)$ decuplets. The fully symmetric wave function for the decuplet state can be constructed as [21].

$$\varphi = \frac{1}{\sqrt{2}} \left(\varphi_{MA}^{SU(6)} \varphi_{MA}^{O(3)} + \varphi_{MS}^{SU(6)} \varphi_{MS}^{O(3)} \right) . \tag{1}$$

Then we obtain:

$$\varphi = \frac{1}{\sqrt{2}} \varphi_S^{SU(3)} \left(\varphi_{MA}^{SU(2)} \varphi_{MA}^{O(3)} + \varphi_{MS}^{SU(2)} \varphi_{MS}^{O(3)} \right), \tag{2}$$

here MA and MS define the mixed antisymmetric and symmetric part of wave function,

$$\varphi_{MA}^{SU(6)} = \varphi_S^{SU(3)} \varphi_{MA}^{SU(2)}, \qquad \varphi_{MS}^{SU(6)} = \varphi_S^{SU(3)} \varphi_{MS}^{SU(2)}. \tag{3}$$

The functions $\varphi_{MA}^{SU(2)}$, $\varphi_{MS}^{SU(2)}$, $\varphi_{MA}^{O(3)}$, $\varphi_{MS}^{O(3)}$ are following:

$$\varphi_{MA}^{SU(2)} = \frac{1}{\sqrt{2}} (\uparrow\downarrow\uparrow - \downarrow\uparrow\uparrow), \qquad \varphi_{MS}^{SU(2)} = \frac{1}{\sqrt{6}} (\uparrow\downarrow\uparrow + \downarrow\uparrow\uparrow - 2\uparrow\uparrow\downarrow), \tag{4}$$

$$\varphi_{MA}^{O(3)} = \frac{1}{\sqrt{2}} (010 - 100), \qquad \varphi_{MS}^{O(3)} = \frac{1}{\sqrt{6}} (010 + 100 - 2 \cdot 001). \tag{5}$$

$\uparrow$ and $\downarrow$ determine the spin directions. 1 and 0 correspond to the excited or nonexcited quarks. The three projections of quark orbital moment are $l_z = 1, 0, -1$. The $(10, 2)$ multiplet with $J^p = \frac{3}{2}^-$ can be obtained using the spin $S = \frac{1}{2}$ and $l_z = 1$, but the $(10, 2)$ multiplet with $J^p = \frac{1}{2}^-$ is determined by the spin $S = \frac{1}{2}$ and $l_z = 0$.

We use the functions (4), (5) and construct the $SU(3)$-function for each particle of multiplet.

For instance, the $SU(3)$-function for Σ^+-hyperon of decuplet have following form:

$$\varphi_S^{SU(3)} = \frac{1}{\sqrt{3}} (usu + suu + uus). \tag{6}$$

Then we obtain the $SU(6) \times O(3)$-function for Σ^+ of the $(10, 2)$ multiplet:

$$\varphi_{\Sigma^+(10,2)} = \frac{\sqrt{6}}{18} \Big(2\{u^1 \downarrow u \uparrow s \uparrow\} + \{s^1 \downarrow u \uparrow u \uparrow\} -$$
$$- \{u^1 \uparrow u \downarrow s \uparrow\} - \{u^1 \uparrow u \uparrow s \downarrow\} - \{s^1 \uparrow u \uparrow u \downarrow\} \Big). \tag{7}$$

Here the parenthesis determine the symmetrical function:

$$\{abc\} \equiv abc + acb + bac + cab + bca + cba. \tag{8}$$

The wave functions of Σ^0- Σ^--hyperons can be constructed by similar way.

For the Δ baryon of $(10, 2)$ multiplet the wave function can be obtained if we replace by $u \leftrightarrow s$ quarks.

For the Δ^{++}-isobar the wave function is following:

$$\varphi_{\Delta^{++}(10,2)} = \frac{\sqrt{2}}{6} \Big(\{u^1 \downarrow u \uparrow u \uparrow\} - \{u^1 \uparrow u \uparrow u \downarrow\} \Big). \tag{9}$$

For the $\Xi^{0,-}$ state of the $(10, 2)$ multiplet the wave function is similar to the $\Sigma^{+,-}$ state with the replacement by $u \leftrightarrow s$ or $d \leftrightarrow s$. The wave function for the Ω^- of the $(10, 2)$ decuplet is determined as the Δ^{++} state with the replacement by $u \to s$ quarks.

The wave function and the method of construction for the multiplets $(8, 2)$, $(8, 4)$ and $(1, 2)$ are similar (see the Appendix A).

3. The three-quark integral equations for the $(\mathbf{70}, \mathbf{1}^-)$ multiplet.

By consideration of the construction of $(\mathbf{70}, \mathbf{1}^-)$ multiplet integral equations we need to using the projectors for the different diquark states. The projectors to the symmetric and antisymmetric states can be obtained as:

$$\frac{1}{2}\left(q_1 q_2 + q_2 q_1\right), \qquad \frac{1}{2}\left(q_1 q_2 - q_2 q_1\right). \tag{10}$$

The spin projectors are following:

$$\frac{1}{2}\left(\uparrow\downarrow + \downarrow\uparrow\right), \qquad \frac{1}{2}\left(\uparrow\downarrow - \downarrow\uparrow\right). \tag{11}$$

The orbital moment excitation projectors are:

$$\frac{1}{2}\left(10 + 01\right), \qquad \frac{1}{2}\left(10 - 01\right). \tag{12}$$

One can obtain the four types of totally symmetric projectors:

$$S = S \cdot S \cdot S = \frac{1}{8}\left(q_1 q_2 + q_2 q_1\right)\left(\uparrow\downarrow + \downarrow\uparrow\right)\left(10 + 01\right), \tag{13}$$

$$S = S \cdot A \cdot A = \frac{1}{8}\left(q_1 q_2 + q_2 q_1\right)\left(\uparrow\downarrow - \downarrow\uparrow\right)\left(10 - 01\right), \tag{14}$$

$$S = A \cdot A \cdot S = \frac{1}{8}\left(q_1 q_2 - q_2 q_1\right)\left(\uparrow\downarrow - \downarrow\uparrow\right)\left(10 + 01\right), \tag{15}$$

$$S = A \cdot S \cdot A = \frac{1}{8}\left(q_1 q_2 - q_2 q_1\right)\left(\uparrow\downarrow + \downarrow\uparrow\right)\left(10 - 01\right). \tag{16}$$

We use these projectors for the consideration of various diquarks:

$u^1 \uparrow s \downarrow$:

$$\begin{aligned}
&\frac{a_1^{0S}}{8}\Big(u^1\uparrow s\downarrow + u^1\downarrow s\uparrow + s^1\uparrow u\downarrow + s^1\downarrow u\uparrow + u\uparrow s^1\downarrow + u\downarrow s^1\uparrow + s\uparrow u^1\downarrow + s\downarrow u^1\uparrow\Big)\\
&+\frac{a_0^{1S}}{8}\Big(u^1\uparrow s\downarrow - u^1\downarrow s\uparrow + s^1\uparrow u\downarrow - s^1\downarrow u\uparrow - u\uparrow s^1\downarrow + u\downarrow s^1\uparrow - s\uparrow u^1\downarrow + s\downarrow u^1\uparrow\Big)\\
&+\frac{a_0^{0S}}{8}\Big(u^1\uparrow s\downarrow - u^1\downarrow s\uparrow - s^1\uparrow u\downarrow + s^1\downarrow u\uparrow + u\uparrow s^1\downarrow - u\downarrow s^1\uparrow - s\uparrow u^1\downarrow + s\downarrow u^1\uparrow\Big)\\
&+\frac{a_1^{1S}}{8}\Big(u^1\uparrow s\downarrow + u^1\downarrow s\uparrow - s^1\uparrow u\downarrow - s^1\downarrow u\uparrow - u\uparrow s^1\downarrow - u\downarrow s^1\uparrow + s\uparrow u^1\downarrow + s\downarrow u^1\uparrow\Big),
\end{aligned} \tag{17}$$

$u^1 \uparrow s \uparrow$:

$$\begin{aligned}
&\frac{a_1^{0S}}{4}\Big(u^1\uparrow s\uparrow + s^1\uparrow u\uparrow + u\uparrow s^1\uparrow + s\uparrow u^1\uparrow\Big) +\\
&+\frac{a_1^{1S}}{4}\Big(u^1\uparrow s\uparrow - s^1\uparrow u\uparrow - u\uparrow s^1\uparrow + s\uparrow u^1\uparrow\Big),
\end{aligned} \tag{18}$$

$u\uparrow s\downarrow$:

$$\frac{a_1^{0S}}{4}\left(u\uparrow s\downarrow + u\downarrow s\uparrow + s\uparrow u\downarrow + s\downarrow u\uparrow\right)+$$

$$+\frac{a_0^{0S}}{4}\left(u\uparrow s\downarrow - u\downarrow s\uparrow - s\uparrow u\downarrow + s\downarrow u\uparrow\right), \tag{19}$$

$u\uparrow s\uparrow$:

$$\frac{a_1^{0S}}{2}\left(u\uparrow s\uparrow + s\uparrow u\uparrow\right). \tag{20}$$

Here the down index determines the value of spin projection, and the up index corresponds to the value of orbital moment.

If we consider the flavors u, d that the results (21)-(24) are similar to (17)-(20) with the replacement by $s \to d$ and the amplitudes a_1^0, a_0^1, a_0^0, a_1^1.

$u^1\uparrow u\downarrow$:

$$\frac{a_1^{0}}{4}\left(u^1\uparrow u\downarrow + u^1\downarrow u\uparrow + u\uparrow u^1\downarrow + u\downarrow u^1\uparrow\right)+$$

$$+\frac{a_0^{1}}{4}\left(u^1\uparrow u\downarrow - u^1\downarrow u\uparrow - u\uparrow u^1\downarrow + u\downarrow u^1\uparrow\right), \tag{21}$$

$u^1\uparrow u\uparrow$:

$$\frac{a_1^{0}}{2}\left(u^1\uparrow u\uparrow + u\uparrow u^1\uparrow\right), \tag{22}$$

$u\uparrow u\downarrow$:

$$\frac{a_1^{0}}{2}\left(u\uparrow u\downarrow + u\downarrow u\uparrow\right), \tag{23}$$

$u\uparrow u\uparrow$:

$$a_1^0\, u\uparrow u\uparrow . \tag{24}$$

Here we consider the projection of orbital moment $l_z = +1$. We use only diquarks 1^+, 0^+, 2^-, 1^-. If we consider the $l_z = 0$ and $l_z = -1$, that we obtain the other diquarks: 1^+, 0^+, 1^-, 0^-. In our model the five types of diquarks 1^+, 0^+, 2^-, 1^-, 0^- are constructed.

For the sake of simplicity we derive the relativistic Faddeev equations using the Σ-hyperon with $J^p = \frac{3}{2}^-$ of the (10,2) multiplets. We use the graphic equations for the functions $A_J(s, s_{ik})$ [19, 20]. In order to represent the amplitude $A_J(s, s_{ik})$ in the form of dispersion relation, it is necessary to define the amplitudes of quark-quark interaction $b_J(s_{ik})$. The pair quarks amplitudes $qq \to qq$ are calculated in the framework of the dispersion N/D method with the input four-fermion interaction with quantum numbers of the gluon [21]. We use results of our relativistic quark model [22] and write down the pair quark amplitudes in the form:

$$b_J(s_{ik}) = \int\limits_{(m_i+m_k)^2}^{\infty} \frac{ds'_{ik}}{\pi}\frac{\rho_J(s'_{ik})G_J(s'_{ik})}{s'_{ik}-s_{ik}}, \tag{25}$$

$$B_J(s_{ik}) = \int\limits_{(m_i+m_k)^2}^{\infty} \frac{ds'_{ik}}{\pi} \frac{\rho_J(s'_{ik}) G_J^2(s'_{ik})}{s'_{ik} - s_{ik}}, \tag{26}$$

$$\rho_J(s_{ik}) = \frac{(m_i+m_k)^2}{4\pi} \left(\alpha_J \frac{s_{ik}}{(m_i+m_k)^2} + \beta_J + \frac{\delta_J}{s_{ik}} \right) \times$$
$$\times \frac{\sqrt{(s_{ik} - (m_i+m_k)^2)(s_{ik} - (m_i-m_k)^2)}}{s_{ik}}. \tag{27}$$

Here G_J is the diquark vertex function; $B_J(s_{ik})$, $\rho_J(s_{ik})$ are the Chew-Mandelstam function [24] and the phase space consequently. s_{ik} is the two-particle subenergy squared (i,k=1,2,3), s is the systems total energy squared.

For the state $J^p = \frac{3}{2}^-$ of the (10,2) multiplet there are three diquarks $J^p = 1^+$, 1^+_S, 1^-_S. The coefficient of Chew-Mandelstam function α_J, β_J and δ_J are given in Table VII.

In the case in question the interacting quarks do not produce bound state, then the integration in dispersion integrals is carried out from $(m_i+m_k)^2$ to ∞.

All diagrams are classified over the last quark pair (Fig.1).

We use the diquark projectors. Then we consider the particle $\Sigma\ \frac{3}{2}^-$ of the $(10,2)$ multiplet again. This wave function contain the contribution $u^1 \downarrow u \uparrow s \uparrow$, which include three diquarks: $u^1 \downarrow u \uparrow$, $u^1 \downarrow s \uparrow$ and $u \uparrow s \uparrow$. The diquark projectors allow us to obtain the equations (28)-(30) (with the definition $\rho_J(s_{ij}) \equiv k_{ij}$).

$$k_{12} \left(\frac{a_1^0 + a_0^1}{4} \left(u^1 \downarrow u \uparrow s \uparrow + u \uparrow u^1 \downarrow s \uparrow \right) + \right.$$
$$\left. + \frac{a_1^0 - a_0^1}{4} \left(u^1 \uparrow u \downarrow s \uparrow + u \downarrow u^1 \uparrow s \uparrow \right) \right) \quad , \tag{28}$$

$$k_{13} \left(\frac{a_1^{0S} + a_0^{1S} + a_0^{0S} + a_1^{1S}}{8} \left(u^1 \downarrow u \uparrow s \uparrow + s \uparrow u \uparrow u^1 \downarrow \right) + \right.$$
$$+ \frac{a_1^{0S} - a_0^{1S} - a_0^{0S} + a_1^{1S}}{8} \left(u^1 \uparrow u \uparrow s \downarrow + s \downarrow u \uparrow u^1 \uparrow \right) +$$
$$+ \frac{a_1^{0S} + a_0^{1S} - a_0^{0S} - a_1^{1S}}{8} \left(s^1 \downarrow u \uparrow u \uparrow + u \uparrow u \uparrow s^1 \downarrow \right) +$$
$$\left. + \frac{a_1^{0S} - a_0^{1S} + a_0^{0S} - a_1^{1S}}{8} \left(s^1 \uparrow u \uparrow u \downarrow + u \downarrow u \uparrow s^1 \uparrow \right) \right) \quad , \tag{29}$$

$$k_{23} \left(\frac{a_1^{0S}}{2} \left(u^1 \downarrow u \uparrow s \uparrow + u^1 \downarrow s \uparrow u \uparrow \right) \right) \quad . \tag{30}$$

Then all members of wave function can be considered. And after the groupping of these members we can obtain, for instance:

$$u^1 \downarrow u \uparrow s \uparrow \left\{ k_{12} \frac{a_1^0 + 3a_0^1}{4} + k_{13} \frac{a_1^{0S} + 3a_0^{1S}}{4} + k_{23}\, a_1^{0S} \right\} \quad . \tag{31}$$

The left side of the diagram (Fig.2) corresponds to the quark interactions. The rigth side of Fig.2 determines the zero approximation (first diagram) and the subsequent pair interactions (second diagram). The contribution to $u^1 \downarrow u \uparrow s \uparrow$ is shown in the Fig.3.

If we group the same members, we obtain the system integral equations for the Σ state with the $J^p = \frac{3}{2}^-$ of the $(10, 2)$ multiplet:

$$\left\{ \begin{array}{l} A_1^0(s, s_{12}) = \lambda \, b_{1^+}(s_{12}) L_{1^+}(s_{12}) + K_{1^+}(s_{12}) \left[\frac{1}{4} A_1^{0S}(s, s_{13}) + \frac{3}{4} A_0^{1S}(s, s_{13}) + \right. \\ \qquad\qquad \left. + \frac{1}{4} A_1^{0S}(s, s_{23}) + \frac{3}{4} A_0^{1S}(s, s_{23}) \right] \\ A_1^{0S}(s, s_{13}) = \lambda \, b_{1_S^+}(s_{13}) L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13}) \left[\frac{1}{2} A_1^0(s, s_{12}) - \frac{1}{4} A_1^{0S}(s, s_{12}) + \right. \\ \qquad\qquad \left. + \frac{3}{4} A_0^{1S}(s, s_{12}) + \frac{1}{2} A_1^0(s, s_{23}) - \frac{1}{4} A_1^{0S}(s, s_{23}) + \frac{3}{4} A_0^{1S}(s, s_{23}) \right] \\ A_0^{1S}(s, s_{23}) = \lambda \, b_{1_S^-}(s_{23}) L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23}) \left[\frac{1}{2} A_1^0(s, s_{12}) + \frac{1}{4} A_1^{0S}(s, s_{12}) + \right. \\ \qquad\qquad \left. + \frac{1}{4} A_0^{1S}(s, s_{12}) + \frac{1}{2} A_1^0(s, s_{13}) + \frac{1}{4} A_1^{0S}(s, s_{13}) + \frac{1}{4} A_0^{1S}(s, s_{13}) \right] \; . \end{array} \right. \tag{32}$$

Here function $L_J(s_{ik})$ has the form

$$L_J(s_{ik}) = \frac{G_J(s_{ik})}{1 - B_J(s_{ik})}. \tag{33}$$

The integral operator $K_J(s_{ik})$ is:

$$K_J(s_{ik}) = L_J(s_{ik}) \int\limits_{(m_i+m_k)^2}^{\infty} \frac{ds'_{ik}}{\pi} \frac{\rho_J(s'_{ik}) G_J(s'_{ik})}{s'_{ik} - s_{ik}} \int\limits_{-1}^{1} \frac{dz}{2} \, . \tag{34}$$

The function $b_J(s_{ik})$ is the truncate function of Chew-Mandelstam. z is the cosine of the angle between the relative momentum of particles i and k in the intermediate state and the momentum of particle j in the final state, taken in the c.m. of the particles i and k. λ is the current constant.

By analogy with the $\Sigma \, \frac{3}{2}^- \, (10, 2)$ state we obtain the rescattering amplitudes of the three various quarks for all P-wave states of the $(\mathbf{70}, \mathbf{1}^-)$ multiplet which satisfy the system of integral equations (Appendix B).

4. The reduced equations of $(\mathbf{70}, \mathbf{1}^-)$ multiplet.

Let us extract two-particle singularities in $A_J(s, s_{ik})$:

$$A_J(s, s_{ik}) = \frac{\alpha_J(s, s_{ik}) b_J(s_{ik}) G_J(s_{ik})}{1 - B_J(s_{ik})}, \tag{35}$$

$\alpha_J(s, s_{ik})$ is the reduced amplitude. Accordingly to this, all integral equations can be rewritten using the reduced amplitudes. For instance, one consider the first equation of system for the $\Sigma \; J^p = \frac{3}{2}^-$ of the $(10, 2)$ multiplet:

$$\alpha_1^0(s,s_{12}) = \lambda + \frac{1}{b_{1^+}(s_{12})} \int\limits_{(m_1+m_2)^2}^{\Lambda_{1^+}(1,2)} \frac{ds'_{12}}{\pi} \frac{\rho_{1^+}(s'_{12})G_{1^+}(s'_{12})}{s'_{12}-s_{12}} \times$$

$$\times \int\limits_{-1}^{1} \frac{dz}{2} \left(\frac{G_{1^+_S}(s'_{13})b_{1^+_S}(s'_{13})}{1-B_{1^+_S}(s'_{13})} \frac{1}{2}\,\alpha_1^{0S}(s,s'_{13}) + \frac{G_{1^-_S}(s'_{13})b_{1^-_S}(s'_{13})}{1-B_{1^-_S}(s'_{13})} \frac{3}{2}\,\alpha_0^{1S}(s,s'_{13}) \right). \qquad (36)$$

The connection between s'_{12} and s'_{13} is [25]:

$$s'_{13} = m_1^2 + m_3^2 - \frac{(s'_{12}+m_3^2-s)\,(s'_{12}+m_1^2-m_2^2)}{2s'_{12}} \pm$$

$$\pm \frac{z}{2s'_{12}} \times \sqrt{(s'_{12}-(m_1+m_2)^2)\,(s'_{12}-(m_1-m_2)^2)} \times$$

$$\times \sqrt{\left(s'_{12}-(\sqrt{s}+m_3)^2\right)\left(s'_{12}-(\sqrt{s}-m_3)^2\right)}\,. \qquad (37)$$

The formula for s'_{23} is similar to (37) with z replaced by $-z$. Thus $A_1^{0S}(s,s'_{13}) + A_1^{0S}(s,s'_{23})$ must be replaced by $2A_1^{0S}(s,s'_{13})$. $\Lambda_J(i,k)$ is the cutoff at the large value of s_{ik}, which determines the contribution from small distances.

The construction of the approximate solution of the (36) is based on the extraction of the leading singularities which are close to the region $s_{ik} = (m_i+m_k)^2$ [25]. Amplitudes with different number of rescattering have the following structure of singularities. The main singularities in s_{ik} are from pair rescattering of the particles i and k. First of all there are threshold square root singularities. Pole singularities are also possible which correspond to the bound states. The diagrams in Fig.2 apart from two-particle singularities have their own specific triangle singularities. Such classification allows us to search the approximate solution of (36) by taking into account some definite number of leading singularities and neglecting all the weaker ones.

We consider the approximation, which corresponds to the single interaction of all three particles (two-particle and triangle singularities) and neglecting all the weaker ones.

The functions $\alpha_J(s,s_{ik})$ are the smooth functions of s_{ik} as compared with the singular part of the amplitude, hence it can be expanded in a series in the singulary point and only the first term of this series should be employed further. As s_0 it is convenient to take the middle point of physical region of Dalitz-plot in which $z=0$. In this case we get from (37) $s_{ik} = s_0 = \frac{s+m_1^2+m_2^2+m_3^2}{m_{12}^2+m_{13}^2+m_{23}^2}$, where $m_{ik} = \frac{m_i+m_k}{2}$. We define the functions $\alpha_J(s,s_{ik})$ and $b_J(s_{ik})$ at the point s_0. Such a choice of point s_0 allows us to replace integral equations (36) by the algebraic equations for the state Σ with $J^p = \frac{3}{2}^-$ of the $(10,2)$ multiplet:

$$\left\{\begin{array}{ll}\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+\\ \qquad\qquad +\frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S\\ \qquad\qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\ \alpha_0^{1S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S\\ \qquad\qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)}+\frac{1}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . & \end{array}\right. \qquad (38)$$

Here the reduced amplitudes for the diquarks 1^+, 1^+_s, 1^-_s are given.

The function $I_{J_1J_2}(s,s_0)$ takes into account singularity which corresponds to the simultaneous vanishing of all propagators in the triangle diagrams.

$$I_{J_1J_2}(s,s_0)=\int\limits_{(m_i+m_k)^2}^{\Lambda_{J_1}}\frac{ds'_{ik}}{\pi}\frac{\rho_{J_1}(s'_{ik})G^2_{J_1}(s'_{ik})}{s'_{ik}-s_{ik}}\int\limits_{-1}^{1}\frac{dz}{2}\frac{1}{1-B_{J_2}(s_{ij})} \qquad (39)$$

The $G_J(s_{ik})$ functions have the smooth dependence from energy s_{ik} [23, 26] therefore we suggest them as constants. The parameters of model: λ_J cut off parameter, g_J vertex constants are chosen dimensionless.

$$g_J=\frac{m_i+m_k}{2\pi}G_J,\ \ \lambda_J=\frac{4\Lambda_J}{(m_i+m_k)^2}. \qquad (40)$$

Here m_i and m_k are quark masses in the intermediate state of the quark loop. Dimensionless parameters g_J and λ_J are supposed to be the constants independent of the quark interaction type. We calculate the system equations and can determine the mass values of the Σ $J^p=\frac{3}{2}^-$ $(10,2)$. We calculate a pole in s which corresponds to the bound state of the three quarks.

By analogy with Σ-hyperon we obtain the system equations for the reduced amplitudes for all particles $(\mathbf{70},\mathbf{1}^-)$ multiplets.

5. Calculation results.

The quark masses ($m_u=m_d=m$ and m_s) are not fixed. In order to fix m and m_s, in any way we assume $m=\frac{1}{3}m_\Delta(1.232)$ and $m=\frac{1}{3}m_\Omega(1.672)$ i.e. the quark masses are $m=0.410\,GeV$ and $m_s=0.557\,GeV$.

The S-wave baryon mass spectra are obtained in good agreement with the experimental data. When we research the excited states the confinement potential can not be neglected. In our case the confinement potential is imitated by the simple increasing of constituent quark masses [27]. The shift of quark mass (parameter $\Delta=160\,MeV$) effectively takes into account the changing of the confinement potential. We have shown that inclusion of only gluon exchange does not lead to the appearance of bound states corresponding to the baryons in the P-wave. The use of mass shift Δ is possible to obtain the mass spectra of P-wave baryons. The similar result for the P-wave mesons was obtained [27].

In the case considered the same parameters Δ for the u, d, s-quarks are choosen. Then the quark masses $m_u = m_d = 0.570\,GeV$ and $m_s = 0.717\,GeV$ are given.

In our model the four parameters are used: gluon coupling constant g_+ and g_- for various parity, cutoff energy parameters λ, λ_s for the nonstrange and strange diquarks.

The parameters $g_+ = 0.69$, $g_- = 0.30$, $\lambda = 14.5$, $\lambda_s = 11.2$ have been determined by the baryon masses: $M_{N\frac{1}{2}^-(8,4)} = 1.650\,GeV$, $M_{N\frac{1}{2}^-(8,2)} = 1.535\,GeV$, $M_{N\frac{3}{2}^-(8,2)} = 1.520\,GeV$, and $M_{\Lambda\frac{3}{2}^-(1,2)} = 1.520\,GeV$. In the table I-VI we present the masses of the nonstrange and strange resonances belonging to the $(\mathbf{70}, \mathbf{1}^-)$ multiplet obtained using the fit of the experimental values [28].

The $(\mathbf{70}, \mathbf{1}^-)$ multiplet include 210 particles, only 30 baryons have different masses. We have predicted 15 masses of baryons.

In the framework of the proposed approximate method of solving the relativistic three-particle problem, we have obtained a satisfactory spectrum of P-wave baryons. The important problem is the mixing of P-wave baryons and the five quark system (cryptoexotic baryons [29] or hybrid baryons [30]).

6. Conclusion.

Many potential model calculations, which retain the one-gluon exchange picture of the quark-quark interactions have gone beyond Isgur and Karl model (see the reviews [31, 32]) for the spectrum and wave functions of baryons in attempt to correct the flaws in the nonrelativistic model [33]. The relativized quark model applied to meson spectroscopy by Capstick and Isgur is similarly considered [33].

In the papers [19, 20] the relativistic generalization of Faddeev equations in the framework of dispersion relation are constructed. We calculated the S-wave baryon masses using the method based on the extraction of leading singularities of the amplitude. The behavior of electromagnetic form factor of the nucleon and hyperon in the region of low and intermediate momentum transfers is determined by [19, 34].

In the framework of the dispersion relation approach the charge radii of S-wave baryon multiplets with $J^p = \frac{1}{2}^+$ are calculated.

In the present paper the relativistic description of three particles amplitudes of P-wave baryons are considered. We take into account the u, d, s-quarks. The mass spectrum of nonstrange and strange states of multiplet $(\mathbf{70}, \mathbf{1}^-)$ are calculated. We use only four parameters for the calculation of 30 baryon masses. We take into account the mass shift of u, d, s quarks which allows us to obtain the P-wave baryon bound states.

Recently, the mass spectrum nonstrange baryons of $(\mathbf{70}, \mathbf{1}^-)$ using $1/N_c$ expansion are calculated [13].

In this paper the orbital-spin-flavor wave function is constructed. The authors solve the problem of difference between the ground state and the excited states for the $(\mathbf{70}, \mathbf{1}^-)$ multiplet.

We also use the orbital-spin-flavor wave function for the construction of integral equations. It allows to calculate the mass spectra for all baryons $(\mathbf{70}, \mathbf{1}^-)$ multiplet.

We can see that the masses of P-wave baryons with $J^p = \frac{1}{2}^-$ are heavier than the masses of states with $J^p = \frac{3}{2}^-$ and $J^p = \frac{5}{2}^-$. This conclusion contradicts to the result of nonrelativistic quark models [31]. The exceptions are the masses of lowest Λ-baryons with $J^p = \frac{1}{2}^-$ and $J^p = \frac{3}{2}^-$.

This model shows some improvements relative to the nonrelativistic model, largely because it does not contain the possibility to separately fit the negative-parity and positive-parity states present in the nonrelativistic model.

We considered the relativistic three-quark equations and calculated the mass spectrum of $(\mathbf{70}, \mathbf{1}^-)$ baryon multiplet.

The following problem of excited baryon description is the mass spectrum of $(\mathbf{70}, \mathbf{L}^+)$, $L^+ = 0, 2$ baryons.

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Appendix A. The P-wave baryon wave functions.

A1. The wave functions of $(\mathbf{10},\mathbf{2})$ decuplet.

We considered this decuplet in the Section 2. The totally symmetric $SU(6)\times O(3)$ wave function for each decuplet particle has the following form:

$$\varphi=\frac{1}{\sqrt{2}}\left(\varphi_{MA}^{SU(6)}\varphi_{MA}^{O(3)}+\varphi_{MS}^{SU(6)}\varphi_{MS}^{O(3)}\right)=\frac{1}{\sqrt{2}}\varphi_{S}^{SU(3)}\left(\varphi_{MA}^{SU(2)}\varphi_{MA}^{O(3)}+\varphi_{MS}^{SU(2)}\varphi_{MS}^{O(3)}\right). \quad (41)$$

The functions $\varphi_{MA}^{SU(2)}$, $\varphi_{MS}^{SU(2)}$, $\varphi_{MA}^{O(3)}$, $\varphi_{MS}^{O(3)}$ are:

$$\varphi_{MA}^{SU(2)}=\frac{1}{\sqrt{2}}\left(\uparrow\downarrow\uparrow-\downarrow\uparrow\uparrow\right),\quad \varphi_{MS}^{SU(2)}=\frac{1}{\sqrt{6}}\left(\uparrow\downarrow\uparrow+\downarrow\uparrow\uparrow-2\uparrow\uparrow\downarrow\right), \quad (42)$$

$$\varphi_{MA}^{O(3)}=\frac{1}{\sqrt{2}}\left(010-100\right),\quad \varphi_{MS}^{O(3)}=\frac{1}{\sqrt{6}}\left(010+100-2\cdot 001\right). \quad (43)$$

For the Σ^{+}-hyperon $SU(3)$-function is:

$$\varphi_{S}^{SU(3)}=\frac{1}{\sqrt{3}}\left(usu+suu+uus\right). \quad (44)$$

Then one obtain the $SU(6)\times O(3)$-function of Σ the $(10,2)$ multiplet:

$$\varphi_{\Sigma^{+}(10,2)}=\frac{\sqrt{6}}{18}\Big(2\{u^{1}\downarrow u\uparrow s\uparrow\}+\{s^{1}\downarrow u\uparrow u\uparrow\}-$$
$$-\{u^{1}\uparrow u\downarrow s\uparrow\}-\{u^{1}\uparrow u\uparrow s\downarrow\}-\{s^{1}\uparrow u\uparrow u\downarrow\}\Big). \quad (45)$$

In the case of Δ the $SU(6)\times O(3)$ wave functions are given:

$$\varphi_{\Delta^{++}(10,2)}=\frac{\sqrt{2}}{6}\Big(\{u^{1}\downarrow u\uparrow u\uparrow\}-\{u^{1}\uparrow u\uparrow u\downarrow\}\Big). \quad (46)$$

The replacement by $u\leftrightarrow s$ or $d\leftrightarrow s$ allows us to obtain the Ξ wave function using the Σ wave function. The Ω^{-} function is similar to the Δ wave function.

A2. The wave functions of $(\mathbf{8},\mathbf{2})$ octet.

The wave functions of octet $\frac{3}{2}^{-},\frac{1}{2}^{-}$ $(8,2)$ multiplet are constructed as:

$$\varphi=\frac{1}{\sqrt{2}}\left(\varphi_{MA}^{SU(6)}\varphi_{MA}^{O(3)}+\varphi_{MS}^{SU(6)}\varphi_{MS}^{O(3)}\right), \quad (47)$$

here

$$\varphi_{MA}^{SU(6)}=\frac{1}{\sqrt{2}}\left(\varphi_{MS}^{SU(3)}\varphi_{MA}^{SU(2)}+\varphi_{MA}^{SU(3)}\varphi_{MS}^{SU(2)}\right), \quad (48)$$

$$\varphi_{MS}^{SU(6)}=\frac{1}{\sqrt{2}}\left(-\varphi_{MS}^{SU(3)}\varphi_{MS}^{SU(2)}+\varphi_{MA}^{SU(3)}\varphi_{MA}^{SU(2)}\right). \quad (49)$$

In the case of Σ^{+} the $SU(3)$ wave functions $\varphi_{MS}^{SU(3)}$ and $\varphi_{MA}^{SU(3)}$ have the following form:

$$\varphi_{MS}^{SU(3)} = \frac{1}{\sqrt{6}}\left(usu + suu - 2uus\right), \quad \varphi_{MA}^{SU(3)} = \frac{1}{\sqrt{2}}\left(usu - suu\right). \tag{50}$$

Then we can obtain the symmetric wave function for Σ^+:

$$\varphi_{\Sigma^+(8,2)} = \frac{\sqrt{6}}{18}\Big(2\{u^1 \uparrow u \downarrow s \uparrow\} + \{s^1 \downarrow u \uparrow u \uparrow\} - \{u^1 \uparrow u \uparrow s \downarrow\} -$$

$$-\{u^1 \downarrow u \uparrow s \uparrow\} - \{s^1 \uparrow u \uparrow u \downarrow\}\Big). \tag{51}$$

By analogy with the Σ^+ we calculate the Σ^0- and Σ^- wave functions.

The nucleon $\frac{3}{2}^-, \frac{1}{2}^-$ $(8,2)$ wave functions are obtained with the replacement by $s \leftrightarrow d$ in Σ^+, and Ξ^0 with replacement by $u \leftrightarrow s$ in Σ^+.

The Λ^0 $SU(3)$ wave functions $\varphi_{MS}^{SU(3)}$ and $\varphi_{MA}^{SU(3)}$ are given:

$$\varphi_{MS}^{SU(3)} = \frac{1}{2}\left(dsu - usd + sdu - sud\right), \tag{52}$$

$$\varphi_{MA}^{SU(3)} = \frac{\sqrt{3}}{6}\left(sdu - sud + usd - dsu - 2dus + 2uds\right). \tag{53}$$

Then the symmetric $SU(6) \times O(3)$ wave function for Λ^0 $\frac{3}{2}^-, \frac{1}{2}^-$ can be considered as:

$$\varphi_{\Lambda^0(8,2)} = \frac{1}{6}\Big(\{u^1 \uparrow d \uparrow s \downarrow\} - \{u^1 \downarrow d \uparrow s \uparrow\} - \{d^1 \uparrow u \uparrow s \downarrow\} +$$

$$+\{d^1 \downarrow u \uparrow s \uparrow\} - \{s^1 \uparrow u \uparrow d \downarrow\} + \{s^1 \uparrow u \downarrow d \uparrow\}\Big). \tag{54}$$

Here we can see that the contribution $u^1 \uparrow s \uparrow d \downarrow$ is absent in the wave function of Λ^0 $\frac{3}{2}^-, \frac{1}{2}^-$ $(8,2)$. One can conclude that the diquark 1^+ do not include into the corresponding amplitude.

A3. The wave function of $(8,4)$ octet.

By analogy with the cases $(10,2)$ and $(8,2)$ we can calculate the $(8,4)$ octet wave functions:

$$\varphi = \frac{1}{\sqrt{2}}\left(\varphi_{MA}^{SU(6)}\varphi_{MA}^{O(3)} + \varphi_{MS}^{SU(6)}\varphi_{MS}^{O(3)}\right), \tag{55}$$

here

$$\varphi_{MA}^{SU(6)} = \varphi_{MA}^{SU(3)}\varphi_{S}^{SU(2)}, \quad \varphi_{MS}^{SU(6)} = \varphi_{MS}^{SU(3)}\varphi_{S}^{SU(2)}. \tag{56}$$

$SU(2)$ wave function is totally symmetric:

$$\varphi_S^{SU(2)} = \uparrow\uparrow\uparrow, \tag{57}$$

$\varphi_{MS}^{SU(3)}$ and $\varphi_{MA}^{SU(3)}$ similar to one of the $(8,2)$ multiplet.

For the Σ^+ $\frac{3}{2}^-, \frac{1}{2}^-$ of $(8,4)$ multiplet one have:

$$\varphi_{\Sigma^+(8,4)} = \frac{\sqrt{2}}{6}\Big(\{s^1 \uparrow u \uparrow u \uparrow\} - \{u^1 \uparrow u \uparrow s \uparrow\}\Big). \tag{58}$$

For the nucleon N we can replace by $s \to d$ in Σ^+, and $u \leftrightarrow s$ for the Ξ^0.
We obtain the wave function of the Λ^0 $(8,4)$:

$$\varphi_{\Lambda^0(8,4)} = \frac{\sqrt{3}}{6}\left(-\{u^1\uparrow d\uparrow s\uparrow\} + \{d^1\uparrow u\uparrow s\uparrow\}\right). \tag{59}$$

A4. The $(\mathbf{1},\mathbf{2})$ singlet wave function.

We must use the other method if we consider the $\frac{3}{2}^-, \frac{1}{2}^-$ $(1,2)$ singlet Λ_1^0. We can use the totally symmetric $SU(6)\times O(3)$ wave function in the form:

$$\varphi = \varphi_A^{SU(3)}\varphi_A^{SU(2)\times O(3)}, \tag{60}$$

here

$$\varphi_A^{SU(3)} = \frac{1}{\sqrt{6}}\left(sdu - sud + usd - dsu + dus - uds\right), \tag{61}$$

$$\varphi_A^{SU(2)\times O(3)} = \frac{1}{\sqrt{2}}\left(\varphi_{MS}^{SU(2)}\varphi_{MA}^{O(3)} - \varphi_{MA}^{SU(2)}\varphi_{MS}^{O(3)}\right). \tag{62}$$

As result we obtain:

$$\begin{aligned}\varphi_{\Lambda_1^0(1,2)} = \frac{\sqrt{3}}{6}\Big(&-\{u^1\uparrow d\uparrow s\downarrow\} + \{u^1\uparrow d\downarrow s\uparrow\} + \{d^1\uparrow u\uparrow s\downarrow\} - \\ &-\{d^1\uparrow u\downarrow s\uparrow\} - \{s^1\uparrow u\uparrow d\downarrow\} + \{s^1\uparrow u\downarrow d\uparrow\}\Big).\end{aligned} \tag{63}$$

Appendix B. The integral equations for the $(\mathbf{70},\mathbf{1}^-)$ multiplet.

B1. $(\mathbf{10},\mathbf{2})$ multiplet.

We can represent the equations for the $\frac{3}{2}^-$ $(10,2)$ multiplet, which is determined by the projection of orbital moment $l_z = +1$. We consider the following states:
$\Delta\ \frac{3}{2}^-$:

$$\begin{cases} A_1^0(s,s_{12}) = \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\left[\frac{1}{4}A_1^0(s,s_{13}) + \frac{3}{4}A_0^1(s,s_{13}) + \right. \\ \qquad\qquad \left. + \frac{1}{4}A_1^0(s,s_{23}) + \frac{3}{4}A_0^1(s,s_{23})\right] \\ A_0^1(s,s_{13}) = \lambda\, b_{1^-}(s_{13})L_{1^-}(s_{13}) + K_{1^-}(s_{13})\left[\frac{3}{4}A_1^0(s,s_{12}) + \frac{1}{4}A_0^1(s,s_{12}) + \right. \\ \qquad\qquad \left. + \frac{3}{4}A_1^0(s,s_{23}) + \frac{1}{4}A_0^1(s,s_{23})\right]\ . \end{cases} \tag{64}$$

$\Sigma\ \frac{3}{2}^-$:

$$\left\{\begin{aligned}
A_1^0(s,s_{12}) &= \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\Big[\tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{3}{4}A_1^{0S}(s,s_{13}) + \\
&\qquad + \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_0^{1S}(s,s_{23})\Big] \\
A_1^{0S}(s,s_{13}) &= \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13})\Big[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \\
&\qquad + \tfrac{3}{4}A_0^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{23}) - \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_0^{1S}(s,s_{23})\Big] \\
A_0^{1S}(s,s_{23}) &= \lambda\, b_{1_S^-}(s_{23})L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23})\Big[\tfrac{1}{2}A_1^0(s,s_{12}) + \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \\
&\qquad + \tfrac{1}{4}A_0^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{13}) + \tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{1}{4}A_0^{1S}(s,s_{13})\Big]\ .
\end{aligned}\right. \tag{65}$$

The system integral equations for the $\Xi\ \frac{3}{2}^-$ are similar to $\Sigma\ \frac{3}{2}^-$ with the replacement by $u \leftrightarrow s$:

$$\left\{\begin{aligned}
A_1^{0SS}(s,s_{12}) &= \lambda\, b_{1_{SS}^+}(s_{12})L_{1_{SS}^+}(s_{12}) + K_{1_{SS}^+}(s_{12})\Big[\tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{3}{4}A_1^{0S}(s,s_{13}) + \\
&\qquad + \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_0^{1S}(s,s_{23})\Big] \\
A_1^{0S}(s,s_{13}) &= \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13})\Big[\tfrac{1}{2}A_1^{0SS}(s,s_{12}) - \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \\
&\qquad + \tfrac{3}{4}A_0^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^{0SS}(s,s_{23}) - \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_0^{1S}(s,s_{23})\Big] \\
A_0^{1S}(s,s_{23}) &= \lambda\, b_{1_S^-}(s_{23})L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23})\Big[\tfrac{1}{2}A_1^{0SS}(s,s_{12}) + \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \\
&\qquad + \tfrac{1}{4}A_0^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^{0SS}(s,s_{13}) + \tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{1}{4}A_0^{1S}(s,s_{13})\Big]\ .
\end{aligned}\right. \tag{66}$$

Then we determine the system integral equations for $\Omega\ \frac{3}{2}^-$ by analogy with Δ (the replacement $u \to s$).

The multiplet $\frac{1}{2}^-$ for $(10,2)$ can be obtain if we use the projection of orbital moment $l_z = 0$. The equations of this multiplet are obtained by the equations, which correspond to the particles of multiplet $\frac{3}{2}^-$ $(10,2)$ (we replace diquark amplitudes): $1^- \to 0^-$ $(A_0^1 \to A_0^{-0})$, $\quad 1_S^- \to 0_S^-$ $\quad (A_0^{1S} \to A_0^{-0S})$.

$\Delta\ \frac{1}{2}^-\ (10,2)$:

$$\begin{cases} A_1^0(s,s_{12}) = \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\left[\frac{1}{4}A_1^0(s,s_{13}) + \frac{3}{4}A_0^{-0}(s,s_{13}) + \right. \\ \qquad\qquad \left. + \frac{1}{4}A_1^0(s,s_{23}) + \frac{3}{4}A_0^{-0}(s,s_{23})\right] \\ A_0^{-0}(s,s_{13}) = \lambda\, b_{0^-}(s_{13})L_{0^-}(s_{13}) + K_{0^-}(s_{13})\left[\frac{3}{4}A_1^0(s,s_{12}) + \frac{1}{4}A_0^{-0}(s,s_{12}) + \right. \\ \qquad\qquad \left. + \frac{3}{4}A_1^0(s,s_{23}) + \frac{1}{4}A_0^{-0}(s,s_{23})\right] \quad . \end{cases} \tag{67}$$

$\Sigma\ \frac{1}{2}^-\ (10,2)$:

$$\begin{cases} A_1^0(s,s_{12}) = \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\left[\frac{1}{4}A_1^{0S}(s,s_{13}) + \frac{3}{4}A_1^{-0S}(s,s_{13}) + \right. \\ \qquad\qquad \left. + \frac{1}{4}A_1^{0S}(s,s_{23}) + \frac{3}{4}A_0^{-0S}(s,s_{23})\right] \\ A_1^{0S}(s,s_{13}) = \lambda\, b_{1^+_S}(s_{13})L_{1^+_S}(s_{13}) + K_{1^+_S}(s_{13})\left[\frac{1}{2}A_1^0(s,s_{12}) - \frac{1}{4}A_1^{0S}(s,s_{12}) + \right. \\ \qquad\qquad \left. + \frac{3}{4}A_0^{-0S}(s,s_{12}) + \frac{1}{2}A_1^0(s,s_{23}) - \frac{1}{4}A_1^{0S}(s,s_{23}) + \frac{3}{4}A_0^{-0S}(s,s_{23})\right] \\ A_0^{-0S}(s,s_{23}) = \lambda\, b_{0^-_S}(s_{23})L_{0^-_S}(s_{23}) + K_{0^-_S}(s_{23})\left[\frac{1}{2}A_1^0(s,s_{12}) + \frac{1}{4}A_1^{0S}(s,s_{12}) + \right. \\ \qquad\qquad \left. + \frac{1}{4}A_0^{-0S}(s,s_{12}) + \frac{1}{2}A_1^0(s,s_{13}) + \frac{1}{4}A_1^{0S}(s,s_{13}) + \frac{1}{4}A_0^{-0S}(s,s_{13})\right] \quad . \end{cases} \tag{68}$$

By analogy with the case $\frac{3}{2}^-\ (10,2)$, the system integral equations for $\Xi\ \frac{1}{2}^-\ (10,2)$ is similar to the case $\Sigma\ \frac{1}{2}^-\ (10,2)$ with the replacement by $u \leftrightarrow s$ and the system equations for $\Omega\ \frac{1}{2}^-\ (10,2)$ is similar to the system for $\Delta\ \frac{1}{2}^-\ (10,2)$ with the replacement by $u \to s$.

B2. $(\mathbf{8},\mathbf{2})$ multiplet.

We determine the equations of multiplet $\frac{3}{2}^-$ $(8,2)$ with $l_z = +1$.
N $\frac{3}{2}^-$ $(8,2)$:

$$\left\{\begin{aligned}
A_1^0(s,s_{12}) &= \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\Big[-\tfrac{1}{8}A_1^0(s,s_{13}) + \tfrac{3}{8}A_0^1(s,s_{13}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{13}) + \tfrac{3}{8}A_1^1(s,s_{13}) - \tfrac{1}{8}A_1^0(s,s_{23}) + \tfrac{3}{8}A_0^1(s,s_{23}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{23}) + \tfrac{3}{8}A_1^1(s,s_{23})\Big] \\
A_0^1(s,s_{13}) &= \lambda\, b_{1^-}(s_{13})L_{1^-}(s_{13}) + K_{1^-}(s_{13})\Big[\tfrac{3}{8}A_1^0(s,s_{12}) - \tfrac{1}{8}A_0^1(s,s_{12}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{12}) + \tfrac{3}{8}A_1^1(s,s_{12}) + \tfrac{3}{8}A_1^0(s,s_{23}) - \tfrac{1}{8}A_0^1(s,s_{23}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{23}) + \tfrac{3}{8}A_1^1(s,s_{23})\Big] \\
A_0^0(s,s_{23}) &= \lambda\, b_{0^+}(s_{23})L_{0^+}(s_{23}) + K_{0^+}(s_{23})\Big[\tfrac{3}{8}A_1^0(s,s_{12}) + \tfrac{3}{8}A_0^1(s,s_{12}) - \\
&\quad - \tfrac{1}{8}A_0^0(s,s_{12}) + \tfrac{3}{8}A_1^1(s,s_{12}) + \tfrac{3}{8}A_1^0(s,s_{13}) + \tfrac{3}{8}A_0^1(s,s_{13}) - \\
&\quad - \tfrac{1}{8}A_0^0(s,s_{13}) + \tfrac{3}{8}A_1^1(s,s_{13})\Big] \\
A_1^1(s,s_{13}) &= \lambda\, b_{2^-}(s_{13})L_{2^-}(s_{13}) + K_{2^-}(s_{13})\Big[\tfrac{3}{8}A_1^0(s,s_{12}) + \tfrac{3}{8}A_0^1(s,s_{12}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{12}) - \tfrac{1}{8}A_1^1(s,s_{12}) + \tfrac{3}{8}A_1^0(s,s_{23}) + \tfrac{3}{8}A_0^1(s,s_{23}) + \\
&\quad + \tfrac{3}{8}A_0^0(s,s_{23}) - \tfrac{1}{8}A_1^1(s,s_{23})\Big]\ .
\end{aligned}\right. \tag{69}$$

$\Sigma\ \frac{3}{2}^-\ (8,2)$:

$$\left\{ \begin{aligned} A_1^0(s,s_{12}) &= \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12}) \left[-\tfrac{1}{8}A_1^{0S}(s,s_{13}) + \tfrac{3}{8}A_0^{1S}(s,s_{13}) + \right. \\ &\quad + \tfrac{3}{8}A_0^{0S}(s,s_{13}) + \tfrac{3}{8}A_1^{1S}(s,s_{13}) - \tfrac{1}{8}A_1^{0S}(s,s_{23}) + \tfrac{3}{8}A_0^{1S}(s,s_{23}) + \\ &\quad \left. + \tfrac{3}{8}A_0^{0S}(s,s_{23}) + \tfrac{3}{8}A_1^{1S}(s,s_{23}) \right] \\ A_1^{0S}(s,s_{13}) &= \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13}) \left[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{5}{8}A_1^{0S}(s,s_{12}) + \right. \\ &\quad + \tfrac{3}{8}A_0^{1S}(s,s_{12}) + \tfrac{3}{8}A_0^{0S}(s,s_{12}) + \tfrac{3}{8}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{23}) - \\ &\quad \left. - \tfrac{5}{8}A_1^{0S}(s,s_{23}) + \tfrac{3}{8}A_0^{1S}(s,s_{23}) + \tfrac{3}{8}A_0^{0S}(s,s_{23}) + \tfrac{3}{8}A_1^{1S}(s,s_{23}) \right] \\ A_0^{1S}(s,s_{23}) &= \lambda\, b_{1_S^-}(s_{23})L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23}) \left[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{1}{8}A_1^{0S}(s,s_{12}) - \right. \\ &\quad - \tfrac{1}{8}A_0^{1S}(s,s_{12}) + \tfrac{3}{8}A_0^{0S}(s,s_{12}) + \tfrac{3}{8}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{13}) - \\ &\quad \left. - \tfrac{1}{8}A_1^{0S}(s,s_{13}) - \tfrac{1}{8}A_0^{1S}(s,s_{13}) + \tfrac{3}{8}A_0^{0S}(s,s_{13}) + \tfrac{3}{8}A_1^{1S}(s,s_{13}) \right] \\ A_0^{0S}(s,s_{13}) &= \lambda\, b_{0_S^+}(s_{13})L_{0_S^+}(s_{13}) + K_{0_S^+}(s_{13}) \left[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{1}{8}A_1^{0S}(s,s_{12}) + \right. \\ &\quad + \tfrac{3}{8}A_0^{1S}(s,s_{12}) - \tfrac{1}{8}A_0^{0S}(s,s_{12}) + \tfrac{3}{8}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{23}) - \\ &\quad \left. - \tfrac{1}{8}A_1^{0S}(s,s_{23}) + \tfrac{3}{8}A_0^{1S}(s,s_{23}) - \tfrac{1}{8}A_0^{0S}(s,s_{23}) + \tfrac{3}{8}A_1^{1S}(s,s_{23}) \right] \\ A_1^{1S}(s,s_{23}) &= \lambda\, b_{2_S^-}(s_{23})L_{2_S^-}(s_{23}) + K_{2_S^-}(s_{23}) \left[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{1}{8}A_1^{0S}(s,s_{12}) + \right. \\ &\quad + \tfrac{3}{8}A_0^{1S}(s,s_{12}) + \tfrac{3}{8}A_0^{0S}(s,s_{12}) - \tfrac{1}{8}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{13}) - \\ &\quad \left. - \tfrac{1}{8}A_1^{0S}(s,s_{13}) + \tfrac{3}{8}A_0^{1S}(s,s_{13}) + \tfrac{3}{8}A_0^{0S}(s,s_{13}) - \tfrac{1}{8}A_1^{1S}(s,s_{13}) \right] \ . \end{aligned} \right. \tag{70}$$

$\Lambda\ \frac{3}{2}^-\ (8,2)$:

$$\left\{\begin{array}{l}
A_0^1(s,s_{12}) = \lambda\, b_{1^-}(s_{12})L_{1^-}(s_{12}) + K_{1^-}(s_{12})\left[\frac{3}{8}A_1^{0S}(s,s_{13}) - \frac{1}{8}A_0^{1S}(s,s_{13}) + \right. \\
\qquad\qquad + \frac{3}{8}A_0^{0S}(s,s_{13}) + \frac{3}{8}A_1^{1S}(s,s_{13}) + \frac{3}{8}A_1^{0S}(s,s_{23}) - \frac{1}{8}A_0^{1S}(s,s_{23}) + \\
\qquad\qquad \left. + \frac{3}{8}A_0^{0S}(s,s_{23}) + \frac{3}{8}A_1^{1S}(s,s_{23})\right] \\
A_1^{0S}(s,s_{13}) = \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13})\left[\frac{1}{2}A_0^1(s,s_{12}) - \frac{1}{8}A_1^{0S}(s,s_{12}) - \right. \\
\qquad\qquad - \frac{1}{8}A_0^{1S}(s,s_{12}) + \frac{3}{8}A_0^{0S}(s,s_{12}) + \frac{3}{8}A_1^{1S}(s,s_{12}) + \frac{1}{2}A_0^1(s,s_{23}) - \\
\qquad\qquad \left. - \frac{1}{8}A_1^{0S}(s,s_{23}) - \frac{1}{8}A_0^{1S}(s,s_{23}) + \frac{3}{8}A_0^{0S}(s,s_{23}) + \frac{3}{8}A_1^{1S}(s,s_{23})\right] \\
A_0^{1S}(s,s_{23}) = \lambda\, b_{1_S^-}(s_{23})L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23})\left[\frac{1}{2}A_0^1(s,s_{12}) + \frac{3}{8}A_1^{0S}(s,s_{12}) - \right. \\
\qquad\qquad - \frac{5}{8}A_0^{1S}(s,s_{12}) + \frac{3}{8}A_0^{0S}(s,s_{12}) + \frac{3}{8}A_1^{1S}(s,s_{12}) + \frac{1}{2}A_0^1(s,s_{13}) + \\
\qquad\qquad \left. + \frac{3}{8}A_1^{0S}(s,s_{13}) - \frac{5}{8}A_0^{1S}(s,s_{13}) + \frac{3}{8}A_0^{0S}(s,s_{13}) + \frac{3}{8}A_1^{1S}(s,s_{13})\right] \\
A_0^{0S}(s,s_{13}) = \lambda\, b_{0_S^+}(s_{13})L_{0_S^+}(s_{13}) + K_{0_S^+}(s_{13})\left[\frac{1}{2}A_0^1(s,s_{12}) + \frac{3}{8}A_1^{0S}(s,s_{12}) - \right. \\
\qquad\qquad - \frac{1}{8}A_0^{1S}(s,s_{12}) - \frac{1}{8}A_0^{0S}(s,s_{12}) + \frac{3}{8}A_1^{1S}(s,s_{12}) + \frac{1}{2}A_0^1(s,s_{23}) + \\
\qquad\qquad \left. + \frac{3}{8}A_1^{0S}(s,s_{23}) - \frac{1}{8}A_0^{1S}(s,s_{23}) - \frac{1}{8}A_0^{0S}(s,s_{23}) + \frac{3}{8}A_1^{1S}(s,s_{23})\right] \\
A_1^{1S}(s,s_{23}) = \lambda\, b_{2_S^-}(s_{23})L_{2_S^-}(s_{23}) + K_{2_S^-}(s_{23})\left[\frac{1}{2}A_0^1(s,s_{12}) + \frac{3}{8}A_1^{0S}(s,s_{12}) - \right. \\
\qquad\qquad - \frac{1}{8}A_0^{1S}(s,s_{12}) + \frac{3}{8}A_0^{0S}(s,s_{12}) - \frac{1}{8}A_1^{1S}(s,s_{12}) + \frac{1}{2}A_0^1(s,s_{13}) + \\
\qquad\qquad \left. + \frac{3}{8}A_1^{0S}(s,s_{13}) - \frac{1}{8}A_0^{1S}(s,s_{13}) + \frac{3}{8}A_0^{0S}(s,s_{13}) - \frac{1}{8}A_1^{1S}(s,s_{13})\right]\ .
\end{array}\right. \tag{71}$$

The system equations of the $\Xi\ \frac{3}{2}^-\ (8,2)$ are similar to the case $\Sigma\ \frac{3}{2}^-\ (8,2)$ by replacement $u \leftrightarrow s$.

As for the case of decuplet, the equations of $\frac{1}{2}^-\ (8,2)$ multiplet ($l_z = 0$) can be determined by the corresponding equation for $\frac{3}{2}^-\ (8,2)$ with replacement by the amplitudes:

$1^- \to 0^-\quad (A_0^1 \to A_0^{-0}),\quad 1_S^- \to 0_S^-\quad (A_0^{1S} \to A_0^{-0S}),$

$2^- \to 1^-\quad (A_1^1 \to A_1^{-0}),\quad 2_S^- \to 1_S^-\quad (A_1^{1S} \to A_1^{-0S}).$

B3. $(8,4)$ **multiplet.**

We consider the states:
$N\ \frac{5}{2}^-\ (8,4)$:

$$\left\{\begin{aligned} A_1^0(s,s_{12}) &= \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\left[\tfrac{1}{4}A_1^0(s,s_{13}) + \tfrac{3}{4}A_1^1(s,s_{13}) + \right. \\ & \left. + \tfrac{1}{4}A_1^0(s,s_{23}) + \tfrac{3}{4}A_1^1(s,s_{23})\right] \\ A_1^1(s,s_{13}) &= \lambda\, b_{2^-}(s_{13})L_{2^-}(s_{13}) + K_{2^-}(s_{13})\left[\tfrac{3}{4}A_1^0(s,s_{12}) + \tfrac{1}{4}A_1^1(s,s_{12}) + \right. \\ & \left. + \tfrac{3}{4}A_1^0(s,s_{23}) + \tfrac{1}{4}A_1^1(s,s_{23})\right] \quad . \end{aligned}\right. \tag{72}$$

$\Sigma\ \frac{5}{2}^-\ (8,4)$:

$$\left\{\begin{aligned} A_1^0(s,s_{12}) &= \lambda\, b_{1^+}(s_{12})L_{1^+}(s_{12}) + K_{1^+}(s_{12})\left[\tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{3}{4}A_1^{1S}(s,s_{13}) + \right. \\ & \left. + \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{1S}(s,s_{23})\right] \\ A_1^{0S}(s,s_{13}) &= \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13})\left[\tfrac{1}{2}A_1^0(s,s_{12}) - \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \right. \\ & \left. + \tfrac{3}{4}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{23}) - \tfrac{1}{4}A_1^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{1S}(s,s_{23})\right] \\ A_1^{1S}(s,s_{23}) &= \lambda\, b_{2_S^-}(s_{23})L_{2_S^-}(s_{23}) + K_{2_S^-}(s_{23})\left[\tfrac{1}{2}A_1^0(s,s_{12}) + \tfrac{1}{4}A_1^{0S}(s,s_{12}) + \right. \\ & \left. + \tfrac{1}{4}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^0(s,s_{13}) + \tfrac{1}{4}A_1^{0S}(s,s_{13}) + \tfrac{1}{4}A_1^{1S}(s,s_{13})\right] \quad . \end{aligned}\right. \tag{73}$$

$\Lambda\ \frac{5}{2}^-\ (8,4)$:

$$\left\{\begin{aligned} A_1^1(s,s_{12}) &= \lambda\, b_{2^-}(s_{12})L_{2^-}(s_{12}) + K_{2^-}(s_{12})\left[\tfrac{3}{4}A_1^{0S}(s,s_{13}) + \tfrac{1}{4}A_1^{1S}(s,s_{13}) + \right. \\ & \left. + \tfrac{3}{4}A_1^{0S}(s,s_{23}) + \tfrac{1}{4}A_1^{1S}(s,s_{23})\right] \\ A_1^{0S}(s,s_{13}) &= \lambda\, b_{1_S^+}(s_{13})L_{1_S^+}(s_{13}) + K_{1_S^+}(s_{13})\left[\tfrac{1}{2}A_1^1(s,s_{12}) + \tfrac{1}{3}A_1^{0S}(s,s_{12}) + \right. \\ & \left. + \tfrac{1}{6}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_1^1(s,s_{23}) + \tfrac{1}{3}A_1^{0S}(s,s_{23}) + \tfrac{1}{6}A_1^{1S}(s,s_{23})\right] \\ A_1^{1S}(s,s_{23}) &= \lambda\, b_{2_S^-}(s_{23})L_{2_S^-}(s_{23}) + K_{2_S^-}(s_{23})\left[\tfrac{1}{2}A_1^1(s,s_{12}) + \tfrac{1}{2}A_1^{0S}(s,s_{12}) + \right. \\ & \left. + \tfrac{1}{2}A_1^1(s,s_{13}) + \tfrac{1}{2}A_1^{0S}(s,s_{13})\right] \quad . \end{aligned}\right. \tag{74}$$

For the particles of $\frac{3}{2}^-$ $(8,4)$ $(l_z = 0)$ and $\frac{1}{2}^-$ $(8,4)$ $(l_z = -1)$, the equations have the similar form with replacement by:

$\frac{3}{2}^-$ $(8,4)$: $\quad 2^- \to 1^- \quad (A_1^1 \to A_1^{-0}), \quad 2_S^- \to 1_S^- \quad (A_1^{1S} \to A_1^{-0S})$.

$\frac{1}{2}^-$ $(8,4)$: $\quad 2^- \to 0^- \quad (A_1^1 \to A_1^{-1}), \quad 2_S^- \to 0_S^- \quad (A_1^{1S} \to A_1^{-1S})$.

B4. $(1,2)$ **multiplet.**

In the case of singlet we obtain only two particles: Λ $\frac{3}{2}^-$ $(l_z = +1)$ and Λ $\frac{1}{2}^-$ $(l_z = 0)$.

Λ $\frac{3}{2}^-$:

$$\left\{\begin{aligned}
A_0^0(s,s_{12}) &= \lambda\, b_{0^+}(s_{12})L_{0^+}(s_{12}) + K_{0^+}(s_{12})\left[\tfrac{1}{4}A_0^{0S}(s,s_{13}) + \tfrac{3}{4}A_1^{1S}(s,s_{13}) + \right.\\
&\qquad \left. + \tfrac{1}{4}A_0^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{1S}(s,s_{23})\right]\\
A_0^{0S}(s,s_{13}) &= \lambda\, b_{0_S^+}(s_{13})L_{0_S^+}(s_{13}) + K_{0_S^+}(s_{13})\left[\tfrac{1}{2}A_0^0(s,s_{12}) - \tfrac{1}{4}A_0^{0S}(s,s_{12}) + \right.\\
&\qquad \left. + \tfrac{3}{4}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_0^0(s,s_{23}) - \tfrac{1}{4}A_0^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{1S}(s,s_{23})\right]\\
A_1^{1S}(s,s_{23}) &= \lambda\, b_{2_S^-}(s_{23})L_{2_S^-}(s_{23}) + K_{2_S^-}(s_{23})\left[\tfrac{1}{2}A_0^0(s,s_{12}) + \tfrac{1}{4}A_0^{0S}(s,s_{12}) + \right.\\
&\qquad \left. + \tfrac{1}{4}A_1^{1S}(s,s_{12}) + \tfrac{1}{2}A_0^0(s,s_{13}) + \tfrac{1}{4}A_0^{0S}(s,s_{13}) + \tfrac{1}{4}A_1^{1S}(s,s_{13})\right] .
\end{aligned}\right. \tag{75}$$

For the Λ $\frac{1}{2}^-$ we replace by $2_S^- \to 1_S^- \quad (A_1^{1S} \to A_1^{-0S})$ and obtain:

$$\left\{\begin{aligned}
A_0^0(s,s_{12}) &= \lambda\, b_{0^+}(s_{12})L_{0^+}(s_{12}) + K_{0^+}(s_{12})\left[\tfrac{1}{4}A_0^{0S}(s,s_{13}) + \tfrac{3}{4}A_1^{-0S}(s,s_{13}) + \right.\\
&\qquad \left. + \tfrac{1}{4}A_0^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{-0S}(s,s_{23})\right]\\
A_0^{0S}(s,s_{13}) &= \lambda\, b_{0_S^+}(s_{13})L_{0_S^+}(s_{13}) + K_{0_S^+}(s_{13})\left[\tfrac{1}{2}A_0^0(s,s_{12}) - \tfrac{1}{4}A_0^{0S}(s,s_{12}) + \right.\\
&\qquad \left. + \tfrac{3}{4}A_1^{-0S}(s,s_{12}) + \tfrac{1}{2}A_0^0(s,s_{23}) - \tfrac{1}{4}A_0^{0S}(s,s_{23}) + \tfrac{3}{4}A_1^{-0S}(s,s_{23})\right]\\
A_1^{-0S}(s,s_{23}) &= \lambda\, b_{1_S^-}(s_{23})L_{1_S^-}(s_{23}) + K_{1_S^-}(s_{23})\left[\tfrac{1}{2}A_0^0(s,s_{12}) + \tfrac{1}{4}A_0^{0S}(s,s_{12}) + \right.\\
&\qquad \left. + \tfrac{1}{4}A_1^{-0S}(s,s_{12}) + \tfrac{1}{2}A_0^0(s,s_{13}) + \tfrac{1}{4}A_0^{0S}(s,s_{13}) + \tfrac{1}{4}A_1^{-0S}(s,s_{13})\right] .
\end{aligned}\right. \tag{76}$$

Appendix C. The system equations of reduced amplitude of the multiplets $(\mathbf{70}, \mathbf{1}^-)$.

C1. The equations of $(\mathbf{10}, \mathbf{2})$ multiplet.

$\Delta\ \frac{3}{2}^-\ (10,2)$:

$$\left\{\begin{array}{ll} \alpha_1^0(s,s_0) = \lambda + \frac{1}{2}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) & 1^+ \\ \qquad +\frac{3}{2}\ \alpha_0^1(s,s_0)\ I_{1^+1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_0^1(s,s_0) = \lambda + \frac{3}{2}\ \alpha_1^0(s,s_0)\ I_{1^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-}(s_0)} & 1^- \\ \qquad +\frac{1}{2}\ \alpha_0^1(s,s_0)\ I_{1^-1^-}(s,s_0)\ . & \end{array}\right. \tag{77}$$

Here α_1^0 and α_0^1 are the reduced diquark amplitudes with $J^p = 1^+$ and 1^-, in the case of $\Delta\ \frac{3}{2}^-\ (10,2)$ one obtain only these two amplitudes.

The equations for $\Sigma\ \frac{3}{2}^-\ (10,2)$:

$$\left\{\begin{array}{ll} \alpha_1^0(s,s_0) = \lambda + \frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+ \\ \qquad +\frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\ \qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0) + \frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\ \alpha_0^{1S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S \\ \qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)} + \frac{1}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . & \end{array}\right. \tag{78}$$

Here we use the reduced amplitudes of three diquarks: 1^+, 1^+_s, 1^-_s.

The Ξ system equations is similar to the case Σ with the replacement by $u \leftrightarrow s$:

$$\left\{\begin{array}{ll} \alpha_1^{0SS}(s,s_0) = \lambda + \frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_{SS}1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+_{ss}}(s_0)} & 1^+_{SS} \\ \qquad +\frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_{SS}1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_{ss}}(s_0)} & \\ \alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{1^+_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\ \qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0) + \frac{3}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\ \alpha_0^{1S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{1^-_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S \\ \qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)} + \frac{1}{2}\ \alpha_0^{1S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . & \end{array}\right. \tag{79}$$

By analogy with the Δ equations we calculate the Ω equations with replacement by $u \rightarrow s$.

Then one considers the multiplet $\frac{1}{2}^-\ (10,2)$. In this case the l_z equal to 0 ($l_z = 0$). The equations of $\frac{1}{2}^-$ multiplets are similar to the $\frac{3}{2}^-$ with replacement by reduced amplitudes: $1^- \rightarrow 0^-$, $\alpha_0^1 \rightarrow \alpha_0^{-0}$ and $1^-_S \rightarrow 0^-_S$, $\alpha_0^{1S} \rightarrow \alpha_0^{-0S}$.

The multiplet $(10, 2)$:
$\Delta\ \frac{1}{2}^-\ (10, 2)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0) = \lambda + \frac{1}{2}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) & 1^+ \\
\qquad\qquad + \frac{3}{2}\ \alpha_0^{-0}(s,s_0)\ I_{1^+0^-}(s,s_0)\ \frac{b_{0^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_0^{-0}(s,s_0) = \lambda + \frac{3}{2}\ \alpha_1^0(s,s_0)\ I_{0^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-}(s_0)} & 0^- \\
\qquad\qquad + \frac{1}{2}\ \alpha_0^{-0}(s,s_0)\ I_{0^-0^-}(s,s_0)\ . &
\end{array}\right. \tag{80}$$

$\Sigma\ \frac{1}{2}^-\ (10, 2)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0) = \lambda + \frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad\qquad + \frac{3}{2}\ \alpha_0^{-0S}(s,s_0)\ I_{1^+0_S^-}(s,s_0)\ \frac{b_{0_s^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1_S^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1_s^+}(s_0)} & 1_S^+ \\
\qquad\qquad - \frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1_S^+1_S^+}(s,s_0) + \frac{3}{2}\ \alpha_0^{-0S}(s,s_0)\ I_{1_S^+0_S^-}(s,s_0)\ \frac{b_{0_s^-}(s_0)}{b_{1_s^+}(s_0)} & \\
\alpha_0^{-0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{0_S^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0_s^-}(s_0)} & 0_S^- \\
\qquad\qquad + \frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{0_S^-1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{0_s^-}(s_0)} + \frac{1}{2}\ \alpha_0^{-0S}(s,s_0)\ I_{0_S^-0_S^-}(s,s_0)\ . &
\end{array}\right. \tag{81}$$

We can obtain that the equations of Σ are similar to Δ with the replacement by $s \to u$.

C2. The equations of $(8, 2)$ multiplet.

$N\ \frac{3}{2}^-\ (8, 2)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0) = \lambda - \frac{1}{4}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) + \frac{3}{4}\ \alpha_0^1(s,s_0)\ I_{1^+1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad + \frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{1^+0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{1^+}(s_0)} + \frac{3}{4}\ \alpha_1^1(s,s_0)\ I_{1^+2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_0^1(s,s_0) = \lambda + \frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{1^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-}(s_0)} - \frac{1}{4}\ \alpha_0^1(s,s_0)\ I_{1^-1^-}(s,s_0) & 1^- \\
\qquad + \frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{1^-0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{1^-}(s_0)} + \frac{3}{4}\ \alpha_1^1(s,s_0)\ I_{1^-2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{1^-}(s_0)} & \\
\alpha_0^0(s,s_0) = \lambda + \frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{0^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^+}(s_0)} + \frac{3}{4}\ \alpha_0^1(s,s_0)\ I_{0^+1^-}(s,s_0)\ \cdot & 0^+ \\
\qquad \cdot \frac{b_{1^-}(s_0)}{b_{0^+}(s_0)} - \frac{1}{4}\ \alpha_0^0(s,s_0)\ I_{0^+0^+}(s,s_0) + \frac{3}{4}\ \alpha_1^1(s,s_0)\ I_{0^+2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{0^+}(s_0)} & \\
\alpha_1^1(s,s_0) = \lambda + \frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{2^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{2^-}(s_0)} + \frac{3}{4}\ \alpha_0^1(s,s_0)\ I_{2^-1^-}(s,s_0)\ \cdot & 2^- \\
\qquad \cdot \frac{b_{1^-}(s_0)}{b_{2^-}(s_0)} + \frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{2^-0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{2^-}(s_0)} - \frac{1}{4}\ \alpha_1^1(s,s_0)\ I_{2^-2^-}(s,s_0)\ . &
\end{array}\right. \tag{82}$$

$\Sigma\ \frac{3}{2}^-\ (8,2)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0) = \lambda - \frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{1^+}(s_0)} + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1^+}(s_0)} & \\
\qquad + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1_S^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1_s^+}(s_0)} & 1_s^+ \\
\qquad - \frac{5}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1_S^+1_S^+}(s,s_0) + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1_S^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{1_s^+}(s_0)} & \\
\qquad + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1_S^+0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1_s^+}(s_0)} + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1_S^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1_s^+}(s_0)} & \\
\alpha_0^{1S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1_S^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1_s^-}(s_0)} & 1_s^- \\
\qquad - \frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1_S^-1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{1_s^-}(s_0)} - \frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1_S^-1_S^-}(s,s_0) & \\
\qquad + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1_S^-0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1_s^-}(s_0)} + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1_S^-2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1_s^-}(s_0)} & \\
\alpha_0^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{0_S^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0_s^+}(s_0)} & 0_s^+ \\
\qquad - \frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0_S^+1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{0_s^+}(s_0)} + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{0_S^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{0_s^+}(s_0)} & \\
\qquad - \frac{1}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0_S^+0_S^+}(s,s_0) + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{0_S^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{0_s^+}(s_0)} & \\
\alpha_1^{1S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{2_S^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{2_s^-}(s_0)} & 2_s^- \\
\qquad - \frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{2_S^-1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{2_s^-}(s_0)} + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{2_S^-1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{2_s^-}(s_0)} & \\
\qquad + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{2_S^-0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{2_s^-}(s_0)} - \frac{1}{4}\ \alpha_1^{1S}(s,s_0)\ I_{2_S^-2_S^-}(s,s_0)\ . &
\end{array}\right. \tag{83}$$

By analogy with the case $(10,2)$, the equations for the $\Xi\ \frac{3}{2}^-\ (8,2)$ are similar to $\Sigma\ \frac{3}{2}^-$ with replacement by $u \leftrightarrow s$:

$$\left\{\begin{array}{ll}
\alpha_1^{0SS}(s,s_0) = \lambda - \frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_{SS}1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+_{ss}}(s_0)} & 1^+_{ss} \\
\quad +\frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_{SS}1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_{ss}}(s_0)} + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+_{SS}0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+_{ss}}(s_0)} & \\
\quad +\frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1^+_{SS}2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^+_{ss}}(s_0)} & \\
\alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{1^+_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{1^+_s}(s_0)} & 1^+_s \\
\quad -\frac{5}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0) + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\quad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+_s}(s_0)} + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1^+_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_0^{1S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{1^-_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{1^-_s}(s_0)} & 1^-_s \\
\quad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)} - \frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0) & \\
\quad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^-_s}(s_0)} + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1^-_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^-_s}(s_0)} & \\
\alpha_0^{0S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{0^+_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{0^+_s}(s_0)} & 0^+_s \\
\quad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0^+_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^+_s}(s_0)} + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{0^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\quad -\frac{1}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0^+_S0^+_S}(s,s_0) + \frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{0^+_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\alpha_1^{1S}(s,s_0) = \lambda + \alpha_1^{0SS}(s,s_0)\ I_{2^-_S1^+_{SS}}(s,s_0)\ \frac{b_{1^+_{ss}}(s_0)}{b_{2^-_s}(s_0)} & 2^-_s \\
\quad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{2^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{2^-_s}(s_0)} + \frac{3}{4}\ \alpha_0^{1S}(s,s_0)\ I_{2^-_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{2^-_s}(s_0)} & \\
\quad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{2^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{2^-_s}(s_0)} - \frac{1}{4}\ \alpha_1^{1S}(s,s_0)\ I_{2^-_S2^-_S}(s,s_0)\ . &
\end{array}\right. \tag{84}$$

$\Lambda\ \frac{3}{2}^-\ (8,2)$:

$$
\left\{
\begin{array}{ll}
\alpha_1^0(s,s_0)=\lambda+\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad -\frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{1^+}(s_0)}+\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1^+}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1_S^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1_s^+}(s_0)} & 1_s^+ \\
\qquad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1_S^+1_S^+}(s,s_0)-\frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1_S^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{1_s^+}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1_S^+0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1_s^+}(s_0)}+\frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1_S^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1_s^+}(s_0)} & \\
\alpha_0^{1S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1_S^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1_s^-}(s_0)} & 1_s^- \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1_S^-1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{1_s^-}(s_0)}-\frac{5}{4}\ \alpha_0^{1S}(s,s_0)\ I_{1_S^-1_S^-}(s,s_0) & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1_S^-0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{1_s^-}(s_0)}+\frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{1_S^-2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{1_s^-}(s_0)} & \\
\alpha_0^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{0_S^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0_s^+}(s_0)} & 0_s^+ \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0_S^+1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{0_s^+}(s_0)}-\frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{0_S^+1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{0_s^+}(s_0)} & \\
\qquad -\frac{1}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0_S^+0_S^+}(s,s_0)+\frac{3}{4}\ \alpha_1^{1S}(s,s_0)\ I_{0_S^+2_S^-}(s,s_0)\ \frac{b_{2_s^-}(s_0)}{b_{0_s^+}(s_0)} & \\
\alpha_1^{1S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{2_S^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{2_s^-}(s_0)} & 2_s^- \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{2_S^-1_S^+}(s,s_0)\ \frac{b_{1_s^+}(s_0)}{b_{2_s^-}(s_0)}-\frac{1}{4}\ \alpha_0^{1S}(s,s_0)\ I_{2_S^-1_S^-}(s,s_0)\ \frac{b_{1_s^-}(s_0)}{b_{2_s^-}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{2_S^-0_S^+}(s,s_0)\ \frac{b_{0_s^+}(s_0)}{b_{2_s^-}(s_0)}-\frac{1}{4}\ \alpha_1^{1S}(s,s_0)\ I_{2_S^-2_S^-}(s,s_0)\ . &
\end{array}
\right.
\qquad (85)
$$

The equations of multiplet $\frac{1}{2}^-\ (8,2)$ correspond to the projection of orbital moment $l_z=0$. The equations of this multiplet are similar to the case $\frac{3}{2}^-$ with replacement by the diquark amplitudes: $1^-\to 0^-$, $\alpha_0^1\to\alpha_0^{-0}$; $2^-\to 1^-$, $\alpha_1^1\to\alpha_1^{-0}$; $1_S^-\to 0_S^-$, $\alpha_0^{1S}\to\alpha_0^{-0S}$; $2_S^-\to 1_S^-$, $\alpha_1^{1S}\to\alpha_1^{-0S}$.

$N\ \frac{1}{2}^-\ (8,2)$:

$$\left\{\begin{array}{l}
\alpha_1^0(s,s_0)=\lambda-\frac{1}{4}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0)+\frac{3}{4}\ \alpha_0^{-0}(s,s_0)\ I_{1^+0^-}(s,s_0)\ \frac{b_{0^-}(s_0)}{b_{1^+}(s_0)} \quad 1^+ \\
\qquad +\frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{1^+0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{1^+}(s_0)}+\frac{3}{4}\ \alpha_1^{-1}(s,s_0)\ I_{1^+1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^+}(s_0)} \\
\alpha_0^{-0}(s,s_0)=\lambda+\frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{0^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-}(s_0)}-\frac{1}{4}\ \alpha_0^{-0}(s,s_0)\ I_{0^-0^-}(s,s_0)\ \ 0^- \\
\qquad +\frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{0^-0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{0^-}(s_0)}+\frac{3}{4}\ \alpha_1^{-0}(s,s_0)\ I_{0^-1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{0^-}(s_0)} \\
\alpha_0^0(s,s_0)=\lambda+\frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{0^+1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^+}(s_0)}+\frac{3}{4}\ \alpha_0^{-0}(s,s_0)\ I_{0^+0^-}(s,s_0)\cdot \quad 0^+ \\
\qquad \cdot\frac{b_{0^-}(s_0)}{b_{0^+}(s_0)}-\frac{1}{4}\ \alpha_0^0(s,s_0)\ I_{0^+0^+}(s,s_0)+\frac{3}{4}\ \alpha_1^{-0}(s,s_0)\ I_{0^+1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{0^+}(s_0)} \\
\alpha_1^{-0}(s,s_0)=\lambda+\frac{3}{4}\ \alpha_1^0(s,s_0)\ I_{1^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-}(s_0)}+\frac{3}{4}\ \alpha_0^{-0}(s,s_0)\ I_{1^-0^-}(s,s_0)\cdot 1^- \\
\qquad \cdot\frac{b_{0^-}(s_0)}{b_{1^-}(s_0)}+\frac{3}{4}\ \alpha_0^0(s,s_0)\ I_{1^-0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{1^-}(s_0)}-\frac{1}{4}\ \alpha_1^{-0}(s,s_0)\ I_{1^-1^-}(s,s_0)\ .
\end{array}\right. \tag{86}$$

$\Sigma\ \frac{1}{2}^-\ (8,2)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0)=\lambda-\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad +\frac{3}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^+0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+}(s_0)}+\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_s \\
\qquad -\frac{5}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{3}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+_s}(s_0)}+\frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_0^{-0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{0^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-_s}(s_0)} & 0^-_s \\
\qquad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^-_s}(s_0)}-\frac{1}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{0^-_S0^-_S}(s,s_0) & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{0^-_s}(s_0)}+\frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{0^-_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^-_s}(s_0)} & \\
\alpha_0^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{0^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^+_s}(s_0)} & 0^+_s \\
\qquad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0^+_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^+_s}(s_0)}+\frac{3}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{0^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\qquad -\frac{1}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0^+_S0^+_S}(s,s_0)+\frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{0^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\alpha_1^{-0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_s \\
\qquad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)}+\frac{3}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^-_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^-_s}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^-_s}(s_0)}-\frac{1}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . &
\end{array}\right. \tag{87}$$

$\Lambda\ \frac{1}{2}^-\ (8,2)$:

$$
\left\{
\begin{array}{ll}
\alpha_1^0(s,s_0) = \lambda + \frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad -\frac{1}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^+0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+}(s_0)} + \frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_s \\
\qquad -\frac{1}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0) - \frac{1}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^+_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^+_s}(s_0)} + \frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_0^{-0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{0^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-_s}(s_0)} & 0^-_s \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^-_s}(s_0)} - \frac{5}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{0^-_S0^-_S}(s,s_0) & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{0^-_s}(s_0)} + \frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{0^-_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^-_s}(s_0)} & \\
\alpha_0^{0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{0^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^+_s}(s_0)} & 0^+_s \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{0^+_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^+_s}(s_0)} - \frac{1}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{0^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\qquad -\frac{1}{4}\ \alpha_0^{0S}(s,s_0)\ I_{0^+_S0^+_S}(s,s_0) + \frac{3}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{0^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\alpha_1^{-0S}(s,s_0) = \lambda + \alpha_1^0(s,s_0)\ I_{1^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_s \\
\qquad +\frac{3}{4}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)} - \frac{1}{4}\ \alpha_0^{-0S}(s,s_0)\ I_{1^-_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^-_s}(s_0)} & \\
\qquad +\frac{3}{4}\ \alpha_0^{0S}(s,s_0)\ I_{1^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^-_s}(s_0)} - \frac{1}{4}\ \alpha_1^{-0S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . &
\end{array}
\right.
\tag{88}
$$

C3. The equations of $(8,4)$ multiplet.

At first we consider the multiplet $\frac{5}{2}^-$ $(8,4)$. In this case the spin $S=\frac{3}{2}$ and $l_z=+1$.
N $\frac{5}{2}^-$ $(8,4)$:

$$\left\{\begin{array}{ll}\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) & 1^+\\ \qquad +\frac{3}{2}\ \alpha_1^1(s,s_0)\ I_{1^+2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_1^1(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^0(s,s_0)\ I_{2^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{2^-}(s_0)} & 2^-\\ \qquad +\frac{1}{2}\ \alpha_1^1(s,s_0)\ I_{2^-2^-}(s,s_0)\ . & \end{array}\right. \tag{89}$$

Σ $\frac{5}{2}^-$ $(8,4)$:

$$\left\{\begin{array}{ll}\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+\\ \qquad +\frac{3}{2}\ \alpha_1^{1S}(s,s_0)\ I_{1^+2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S\\ \qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{3}{2}\ \alpha_1^{1S}(s,s_0)\ I_{1^+_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\ \alpha_1^{1S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{2^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{2^-_s}(s_0)} & 2^-_S\\ \qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{2^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{2^-_s}(s_0)}+\frac{1}{2}\ \alpha_1^{1S}(s,s_0)\ I_{2^-_S2^-_S}(s,s_0)\ . & \end{array}\right. \tag{90}$$

Λ $\frac{5}{2}^-$ $(8,4)$:

$$\left\{\begin{array}{ll}\alpha_1^1(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^{0S}(s,s_0)\ I_{2^-1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{2^-}(s_0)} & 2^-\\ \qquad +\frac{1}{2}\ \alpha_1^{1S}(s,s_0)\ I_{2^-2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{2^-}(s_0)} & \\ \alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^1(s,s_0)\ I_{1^+_S2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S\\ \qquad +\frac{2}{3}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{1}{3}\ \alpha_1^{1S}(s,s_0)\ I_{1^+_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\ \alpha_1^{1S}(s,s_0)=\lambda+\alpha_1^1(s,s_0)\ I_{2^-_S2^-}(s,s_0)\ \frac{b_{2^-}(s_0)}{b_{2^-_s}(s_0)} & 2^-_S\\ \qquad +\ \alpha_1^{0S}(s,s_0)\ I_{2^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{2^-_s}(s_0)}\ . & \end{array}\right. \tag{91}$$

We derive the equations for the multiplet $\frac{3}{2}^-$ $(8,4)$. One use the spin $S=\frac{3}{2}$ and $l_z=0$.
N $\frac{3}{2}^-$ $(8,4)$:

$$\left\{\begin{array}{ll}\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) & 1^+\\ \qquad +\frac{3}{2}\ \alpha_1^{-0}(s,s_0)\ I_{1^+1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^+}(s_0)} & \\ \alpha_1^{-0}(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^0(s,s_0)\ I_{1^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-}(s_0)} & 1^-\\ \qquad +\frac{1}{2}\ \alpha_1^{-0}(s,s_0)\ I_{1^-1^-}(s,s_0)\ . & \end{array}\right. \tag{92}$$

$\Sigma\ \frac{3}{2}^-\ (8,4)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad\qquad +\frac{3}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\
\qquad\qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{3}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_1^{-0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S \\
\qquad\qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)}+\frac{1}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . &
\end{array}\right. \tag{93}$$

$\Lambda\ \frac{3}{2}^-\ (8,4)$:

$$\left\{\begin{array}{ll}
\alpha_1^{-0}(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^-1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-}(s_0)} & 1^- \\
\qquad\qquad +\frac{1}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{1^-1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^-}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^{-0}(s,s_0)\ I_{1^+_S1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\
\qquad\qquad +\frac{2}{3}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{1}{3}\ \alpha_1^{-0S}(s,s_0)\ I_{1^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_1^{-0S}(s,s_0)=\lambda+\alpha_1^{-0}(s,s_0)\ I_{1^-_S1^-}(s,s_0)\ \frac{b_{1^-}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S \\
\qquad\qquad +\ \alpha_1^{0S}(s,s_0)\ I_{1^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^-_s}(s_0)}\ . &
\end{array}\right. \tag{94}$$

We use the spin $S=\frac{3}{2}$ and the moment projection $l_z=-1$ and obtain the equations of multiplet $\frac{1}{2}^-\ (8,4)$.

$N\ \frac{1}{2}^-\ (8,4)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^0(s,s_0)\ I_{1^+1^+}(s,s_0) & 1^+ \\
\qquad\qquad +\frac{3}{2}\ \alpha_1^{-1}(s,s_0)\ I_{1^+0^-}(s,s_0)\ \frac{b_{0^-}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{-1}(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^0(s,s_0)\ I_{0^-1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-}(s_0)} & 0^- \\
\qquad\qquad +\frac{1}{2}\ \alpha_1^{-1}(s,s_0)\ I_{0^-0^-}(s,s_0)\ . &
\end{array}\right. \tag{95}$$

$\Sigma\ \frac{1}{2}^-\ (8,4)$:

$$\left\{\begin{array}{ll}
\alpha_1^0(s,s_0)=\lambda+\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{1^+}(s_0)} & 1^+ \\
\qquad\qquad +\frac{3}{2}\ \alpha_1^{-1S}(s,s_0)\ I_{1^+0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{1^+_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\
\qquad\qquad -\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{3}{2}\ \alpha_1^{-1S}(s,s_0)\ I_{1^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_1^{-1S}(s,s_0)=\lambda+\alpha_1^0(s,s_0)\ I_{0^-_S1^+}(s,s_0)\ \frac{b_{1^+}(s_0)}{b_{0^-_s}(s_0)} & 0^-_S \\
\qquad\qquad +\frac{1}{2}\ \alpha_1^{0S}(s,s_0)\ I_{0^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^-_s}(s_0)}+\frac{1}{2}\ \alpha_1^{-1S}(s,s_0)\ I_{0^-_S0^-_S}(s,s_0)\ . &
\end{array}\right. \tag{96}$$

$\Lambda\ \frac{1}{2}^-\ (8,4)$:

$$\left\{\begin{array}{ll}
\alpha_1^{-1}(s,s_0)=\lambda+\frac{3}{2}\ \alpha_1^{0S}(s,s_0)\ I_{0^-1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^-}(s_0)} & 0^- \\
\qquad\qquad\qquad +\frac{1}{2}\ \alpha_1^{-1S}(s,s_0)\ I_{0^-0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{0^-}(s_0)} & \\
\alpha_1^{0S}(s,s_0)=\lambda+\alpha_1^{-1}(s,s_0)\ I_{1^+_S0^-}(s,s_0)\ \frac{b_{0^-}(s_0)}{b_{1^+_s}(s_0)} & 1^+_S \\
\qquad\qquad\qquad +\frac{2}{3}\ \alpha_1^{0S}(s,s_0)\ I_{1^+_S1^+_S}(s,s_0)+\frac{1}{3}\ \alpha_1^{-1S}(s,s_0)\ I_{1^+_S0^-_S}(s,s_0)\ \frac{b_{0^-_s}(s_0)}{b_{1^+_s}(s_0)} & \\
\alpha_1^{-1S}(s,s_0)=\lambda+\alpha_1^{-1}(s,s_0)\ I_{0^-_S0^-}(s,s_0)\ \frac{b_{0^-}(s_0)}{b_{0^-_s}(s_0)} & 0^-_S \\
\qquad\qquad\qquad +\ \alpha_1^{0S}(s,s_0)\ I_{0^-_S1^+_S}(s,s_0)\ \frac{b_{1^+_s}(s_0)}{b_{0^-_s}(s_0)}\ . &
\end{array}\right. \tag{97}$$

C4. The equations of $(\mathbf{1},\mathbf{2})$ singlet.

$\Lambda\ \frac{3}{2}^-\ (1,2)$:

$$\left\{\begin{array}{ll}
\alpha_0^{0}(s,s_0)=\lambda+\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{0^+0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{0^+}(s_0)} & 0^+ \\
\qquad\qquad\qquad +\frac{3}{2}\ \alpha_1^{1S}(s,s_0)\ I_{0^+2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{0^+}(s_0)} & \\
\alpha_0^{0S}(s,s_0)=\lambda+\alpha_0^{0}(s,s_0)\ I_{0^+_S0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{0^+_s}(s_0)} & 0^+_S \\
\qquad\qquad\qquad -\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{0^+_S0^+_S}(s,s_0)+\frac{3}{2}\ \alpha_1^{1S}(s,s_0)\ I_{0^+_S2^-_S}(s,s_0)\ \frac{b_{2^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\alpha_1^{1S}(s,s_0)=\lambda+\alpha_0^{0}(s,s_0)\ I_{2^-_S0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{2^-_s}(s_0)} & 2^-_S \\
\qquad\qquad\qquad +\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{2^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{2^-_s}(s_0)}+\frac{1}{2}\ \alpha_1^{1S}(s,s_0)\ I_{2^-_S2^-_S}(s,s_0)\ . &
\end{array}\right. \tag{98}$$

$\Lambda\ \frac{1}{2}^-\ (1,2)$:

$$\left\{\begin{array}{ll}
\alpha_0^{0}(s,s_0)=\lambda+\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{0^+0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{0^+}(s_0)} & 0^+ \\
\qquad\qquad\qquad +\frac{3}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{0^+1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^+}(s_0)} & \\
\alpha_0^{0S}(s,s_0)=\lambda+\alpha_0^{0}(s,s_0)\ I_{0^+_S0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{0^+_s}(s_0)} & 0^+_S \\
\qquad\qquad\qquad -\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{0^+_S0^+_S}(s,s_0)+\frac{3}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{0^+_S1^-_S}(s,s_0)\ \frac{b_{1^-_s}(s_0)}{b_{0^+_s}(s_0)} & \\
\alpha_1^{-0S}(s,s_0)=\lambda+\alpha_0^{0}(s,s_0)\ I_{1^-_S0^+}(s,s_0)\ \frac{b_{0^+}(s_0)}{b_{1^-_s}(s_0)} & 1^-_S \\
\qquad\qquad\qquad +\frac{1}{2}\ \alpha_0^{0S}(s,s_0)\ I_{1^-_S0^+_S}(s,s_0)\ \frac{b_{0^+_s}(s_0)}{b_{1^-_s}(s_0)}+\frac{1}{2}\ \alpha_1^{-0S}(s,s_0)\ I_{1^-_S1^-_S}(s,s_0)\ . &
\end{array}\right. \tag{99}$$

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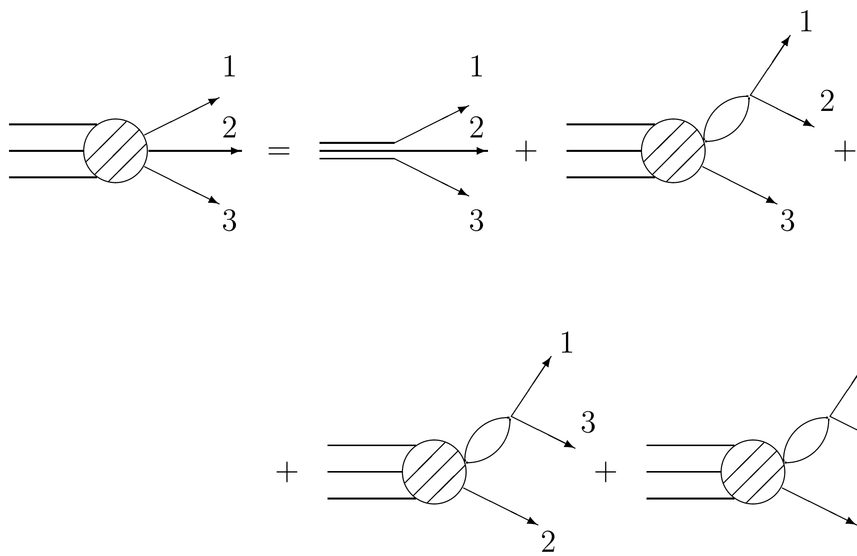

Fig.1. The contribution of diagrams at the last pair of the interacting particles.

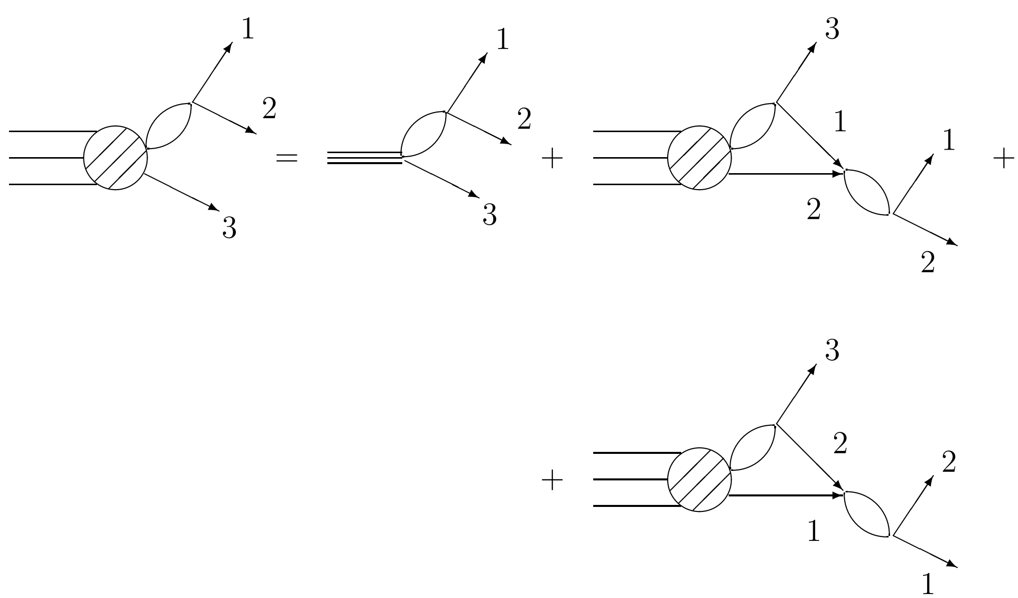

Fig.2. Graphic representation of the equations for the amplitude $A_1(s, s_{ik})$.

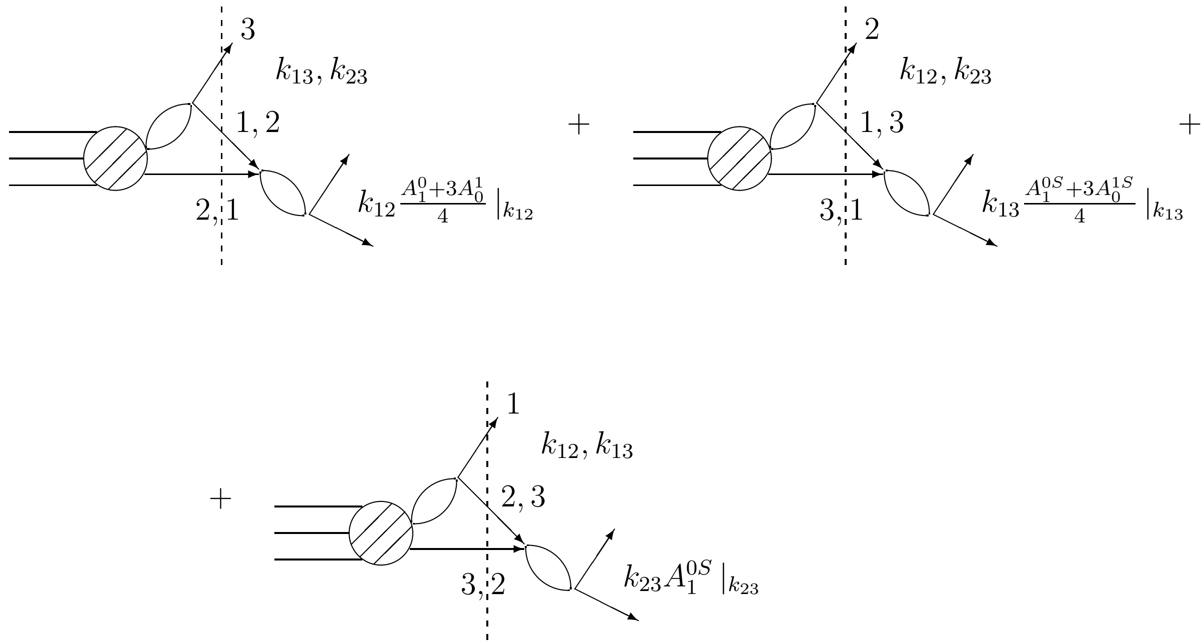

Fig.3. The contribution of the diagrams with the rescattering.

Table I.
The Δ-isobar masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{3}{2}^-$ $(10, 2)$	D_{33}	1.565	1.700
$\frac{1}{2}^-$ $(10, 2)$	S_{31}	1.650	1.620

The parameters of model (Tables I-VI): gluon coupling constant $g_+ = 0.69$, $g_- = 0.3$, cutoff energy parameters $\lambda = 14.5$, $\lambda_s = 11.2$.

Table II.
The nucleon masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{5}{2}^-$ $(8, 4)$	D_{15}	1.606	1.675
$\frac{3}{2}^-$ $(8, 4)$	D_{13}	1.565	1.700
$\frac{1}{2}^-$ $(8, 4)$	S_{11}	1.650	1.650
$\frac{3}{2}^-$ $(8, 2)$	D_{13}	1.520	1.520
$\frac{1}{2}^-$ $(8, 2)$	S_{11}	1.535	1.535

Table III.
The Σ-hyperon masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{3}{2}^-$ $(10, 2)$	D_{33}	1.675	–
$\frac{1}{2}^-$ $(10, 2)$	S_{31}	1.785	–
$\frac{5}{2}^-$ $(8, 4)$	D_{15}	1.726	1.775
$\frac{3}{2}^-$ $(8, 4)$	D_{13}	1.675	1.670
$\frac{1}{2}^-$ $(8, 4)$	S_{11}	1.785	1.750
$\frac{3}{2}^-$ $(8, 2)$	D_{13}	1.590	1.580
$\frac{1}{2}^-$ $(8, 2)$	S_{11}	1.639	1.620

Table IV.
The Λ-hyperon masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{5}{2}^-$ $(8, 4)$	D_{15}	1.634	–
$\frac{3}{2}^-$ $(8, 4)$	D_{13}	1.581	–
$\frac{1}{2}^-$ $(8, 4)$	S_{11}	1.702	–
$\frac{3}{2}^-$ $(8, 2)$	D_{13}	1.568	–
$\frac{1}{2}^-$ $(8, 2)$	S_{11}	1.617	–
$\frac{3}{2}^-$ $(1, 2)$	D_{03}	1.520	1.520
$\frac{1}{2}^-$ $(1, 2)$	S_{01}	1.437	1.405

Table V.
The Ξ-hyperon masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{3}{2}^-$ $(10, 2)$	D_{33}	1.765	–
$\frac{1}{2}^-$ $(10, 2)$	S_{31}	1.905	–
$\frac{5}{2}^-$ $(8, 4)$	D_{15}	1.823	–
$\frac{3}{2}^-$ $(8, 4)$	D_{13}	1.765	1.820
$\frac{1}{2}^-$ $(8, 4)$	S_{11}	1.905	–
$\frac{3}{2}^-$ $(8, 2)$	D_{13}	1.681	–
$\frac{1}{2}^-$ $(8, 2)$	S_{11}	1.741	–

Table VI.
The Ω-hyperon masses of multiplet $(70, 1^-)$.

Multiplet	Baryon	Mass (GeV)	Mass (GeV) (exp.)
$\frac{3}{2}^-$ $(10, 2)$	D_{33}	1.889	–
$\frac{1}{2}^-$ $(10, 2)$	S_{31}	2.040	–

Table VII. Coefficient of Ghew-Mandelstam function for the different diquarks.

	α_J	β_J	δ_J
1^+	$\frac{1}{3}$	$\frac{4m_i m_k}{3(m_i+m_k)^2} - \frac{1}{6}$	$-\frac{1}{6}(m_i - m_k)^2$
0^+	$\frac{1}{2}$	$-\frac{1}{2}\frac{(m_i-m_k)^2}{(m_i+m_k)^2}$	0
0^-	0	$\frac{1}{2}$	$-\frac{1}{2}(m_i - m_k)^2$
1^-	$\frac{1}{2}$	$-\frac{1}{2}\frac{(m_i-m_k)^2}{(m_i+m_k)^2}$	0
2^-	$\frac{3}{10}$	$\frac{1}{5}\left(1 - \frac{3}{2}\frac{(m_i-m_k)^2}{(m_i+m_k)^2}\right)$	$-\frac{1}{5}(m_i - m_k)^2$